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ASTRONOMY

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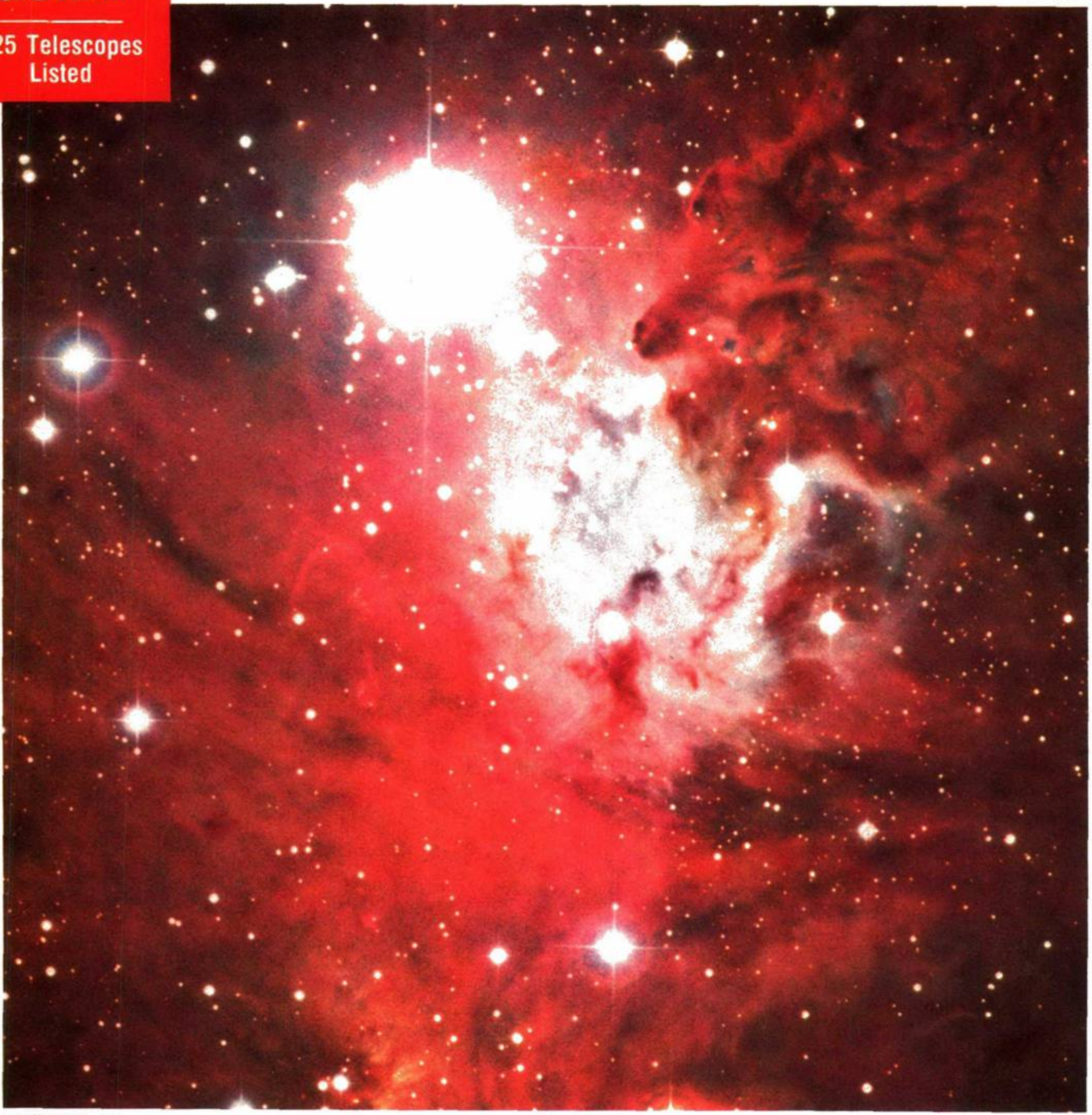

Emission Nebula NGC 2264

Meade 10″ Model 2120/LX6. Shown with optional Digital Readout System and Superwedge.

Background photo: The Lagoon Nebula (M8). A 20-minute exposure with the Meade 8″ Model 2080/LX6.

Meade® 10″ 2120/LX6: Number One Worldwide.

Now Available with the Meade Superwedge™ for Even More Stability!

The Meade 10″ Wide-Field Model 2120/LX6 is now the World's most popular large-aperture Schmidt-Cassegrain. Meade 10″ 2120 models, in fact, continue to outsell most competing *8″* Schmidt-Cassegrain models!

The 2120/LX6 has achieved this dominant position because it simply offers more value: more features, more accessories, more aperture, more performance for the money. When you buy a Meade 10″ Model 2120/LX6, here's some of what you receive as *standard equipment:*

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☐ *Optional Digital Readouts:* Find faint objects in seconds using the Meade Digital Readout System (DRS). The DRS adds easily and quickly to 8″ and 10″ LX6 models and permits precise monitoring of telescope position in RA and Dec, directly from the hand controller.

■ **Advanced-Design Power Panel**—Virtually every modern electronic accessory can be plugged into the telescope's power panel. Accessories including the Meade CAT Computer Aided Telescope system, #1200A Electric Focuser, Digital Readout System, Illuminated Reticle Eyepiece, and more.

■ **A Specifications Listing** that includes 9 x 60mm Polar Illuminated Viewfinder, 2″ Diagonal Mirror (itself a $200 option on competing models), Multi-Coated Optics Group, and Super Plössl 26mm eyepiece.

See your Meade dealer for full details on the 10″ Model 2120/LX6—the telescope that's Number One among serious amateurs worldwide.

■ **NEW! Meade Superwedge**—The equatorial wedge included as standard equipment with the 2120/LX6 is satisfactory for all normal applications of the telescope. Observers who require extreme stability in the most demanding applications may specify the new Superwedge in place of the standard wedge, at additional cost. The Superwedge includes microfine azimuth and elevation controls, and reduces telescope damping time by about 80%.

Add the Superwedge to your Meade 10″ Schmidt-Cassegrain.

The Meade Superwedge is available separately for retrofitting to existing Meade 10″ Schmidt-Cassegrain telescope Models 2120, 2120/LX3, 2120/LX5, and 2120/LX6. Call or write your Meade dealer for details.

Ever expect to see the Great Nebula in Orion (M42) as a glowing blue-green ember? Or resolve the Hercules globular cluster (M13) to the core? Or observe the dust lanes and spiral structure in the Whirlpool Galaxy (M51)? Not just photographically, but **visually.** You can, and can afford to, observe these and countless hundreds of other objects as you've never seen them before, with a Meade Deep-Space DS-10 or DS-16 telescope.

Consider the possibilities in astrophotography: With exposures of *less than 15 minutes,* capture the glowing yellow-red detail of the Ring Nebula (M57), including the 15th-magnitude central star; or the complete red, blue, and green structure of the Orion Nebula, including the diffuse outer loop; or the fiery-red gaseous detail of the Omega Nebula (M17). Combining giant apertures with fast f/4.5 focal ratios, the Meade DS-10 and DS-16 permit photo exposure times so short even a beginner can obtain exciting results.

Each DS-10 and DS-16 is supplied as a complete operating telescope. Included as standard equipment on both telescopes are the complete optical tube assembly, *equatorial* mount, low-profile pier and tripod legs. Electric motor drives, as well as a long list of equipment for advanced applications, are available optionally.

At **$895** for the DS-10 and **$1695** for the DS-16, Meade Deep-Space telescopes offer giant apertures at very reasonable price levels. Order one today from your Meade dealer—and observe or photograph deep-space as you never thought possible.

SPECIFICATIONS:

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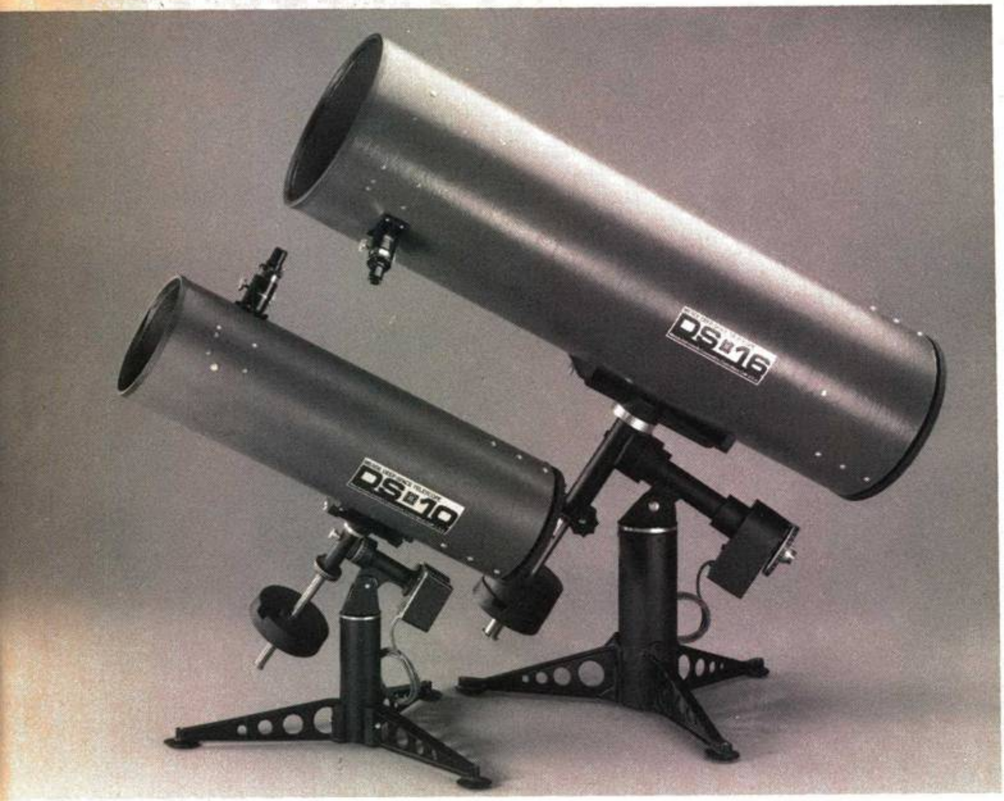
Meade DS-16: 16″ f/4.5 Reflecting Telescope — Includes null-figured, diffraction-limited, Pyrex parabolic primary mirror and matching (4.00″ M.A.) elliptical flat secondary; flotation mirror cell; #67 rack-and-pinion focuser; MA 25mm (73X) coated eyepiece; Sonotube 18″ I.D. x 68″ long, sealed and attractively Zolatone coated; all-metal, precision-machined equatorial mount, with ultrasmooth Nylon bearings, 1½″ solid steel shafts, and 5″ dia. polar thrust surface; low-profile pier and tripod legs. **$1695**

Optional Features — #787 Electric Motor Drive (DS-10); #897 Worm Gear Motor Drive (DS-16); Sealmaster Ball Bearing polar axis (DS-16); 6 x 30mm and 8 x 50mm Viewfinders; Manual Declination Controls; Single- and Dual-Axis Drive Correctors; 2.4″ and 3.1″ Photo-Guide Telescopes; Giant #680 Focuser for 1¼″ & 2″ O.D. eyepieces; Setting Circles.

Meade Deep-Space Telescopes: Giant Apertures at Super Prices!



Meade DS-10 and DS-16, shown with optional motor drives, setting circles, giant focusers.

Meade DS-16 Astrophotos:
(top) Southern region of the Andromeda Galaxy (M31); *(lower)* The Horsehead Nebula. Both photos by Paul Roques.

Dealer Locations and Assistance

For your nearest Meade dealer location, or for free telescope information and assistance, call Meade Instruments toll-free from anywhere in the continental U.S.A. (except California): **1-800-854-7485.** From all other areas, including California, call direct (714) 556-2291.

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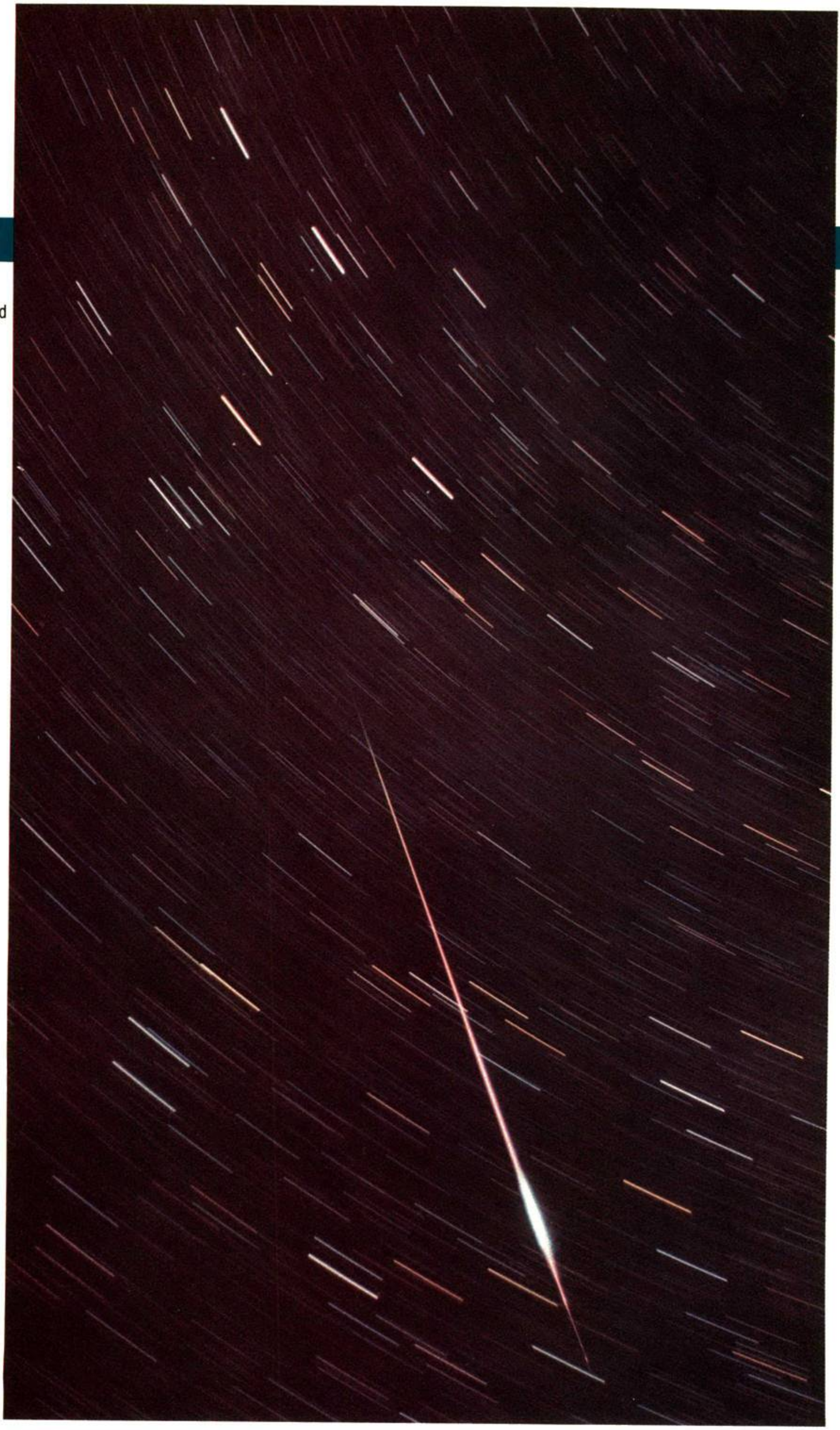
ON THE COVER: Billows of dusty red hydrogen gas surround the bright star S Monocerotis in the heart of a rich star-forming region.



A BRILLIANT PERSEID fireball streaks out of Cassiopeia in Michael Shin's camera-on-tripod astrophoto taken in 1988. The meteor was bright enough to let Shin read the small print on a Milky Way candy bar wrapper!

ASTRONOMY

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Behind the Scenes

AN OUTSTANDING OCCULTATION

The star crept closer and closer to the rings — and suddenly was gone! I squeezed down closer to the eyepiece and whispered to the microphone in my hand, "It just went out! Zero."

It was a few minutes before 1:00 on the morning of July 3 and along with thousands of ASTRONOMY readers, I was watching the planet Saturn occult 28 Sagittarii (see "You Can See a Star Flicker Behind Saturn's Rings," June 1989). For three hours I watched as Saturn slowly passed over the star.

The faint, ruddy spark of light in the rings revealed detail too fine to see through any telescope. The A ring showed quick flashes — ring gaps —at both beginning and end. Cassini's division was far from transparent: sharp interruptions spoke of unseen ringlets. Ring B was broad and dense, except for half-a-dozen gaps toward the inner edge.

Ring C was exciting. 28 Sagittarii bounced from full brightness to totally obscured and back again many times. At one point as I was making estimates every few seconds, I whispered "This is wild!" into the microphone and marveled at the magnificence of the thing I was seeing.

As my wife and I ate breakfast that morning at the local truck-stop restaurant, I felt foggy in the head but luxuriously happy. I wanted to contemplate, celebrate, and savor so fine an event; coffee, eggs, and toast had never tasted so good. When I walked into the office that morning, ASTRONOMY's editors were animatedly talking about the occultation.

Robert observed with his trusty twenty-year-old Criterion reflector. Because of trees in his yard, Jeff watched the event through a 3-inch refractor that he could pick up and carry. Rich followed the progress of 28 Sagittarii with an 80mm Jason from the collection of refractors tested in this issue. Dave observed through his C8 until he was fogged out halfway through. And Tom observed with Bruce Bond, the artist who painted the occultation in our June issue.

Nights like this charge editorial batteries run down from never-ending deadlines, committee meetings, and writing memos. A night under the stars — in this case an extraordinary night — rewards the bug bites, the cloudy nights, the next-day fuzzies, and the thousand other frustrations with priceless moments of sublime beauty.

Sincerely,

Richard Berry

Richard Berry
Editor-in-Chief

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Letters

How Do You Dew?

Does your finder scope say "I dew" when you didn't even propose? The solution to the dew problem could be easier than you think. Steve Hopkins, president of the Toledo Astronomical Association (I have to give credit where credit is "dew"), suggested that I solve the dew problem by sliding a painted and varnished cardboard tube, made from the inside of a roll of wrapping paper, over the end of my 8x50 finder. It couldn't work, could it? After all, it was free! But, I dew not have any more problems with dew. — *Frank Myers, Rossford, Ohio*

One Small Slip

There seems to be a most curious anomaly in "I'm at the Foot of the Ladder . . ." by Harry Hurt III (July 1989). You quote Neil Armstrong as saying, "That's one small step for . . . man, one giant leap for mankind." I watched the original broadcast and clearly recall Armstrong saying, "That's one small step for *a* man, one giant leap for mankind."

After seeing a number of recent video replays in which the "a" was deleted, however, I began to question my memory. It seems to me that the whole flavor and meaning is altered by the deletion of the "a." Can you please explain this? — *Barry R. McElmurry, Rancho Palos Verdes, California*

— As Harry Hurt III documents in For All Mankind, *Neil Armstrong intended to say "That's one small step for a man, one giant leap for mankind." But in the heat of the moment, Armstrong failed to insert the article "a" in his statement. NASA's official line was that Armstrong had spoken the "a," but it was lost in the radio transmission. Armstrong explains, "I thought it had been included. Although [it is] technically possible that the VOX didn't pick it up and transmit it, my listening to the recording indicates it is more likely that it was just omitted."*

Astronaut Arithmetic

I noticed one slight error in the introductory paragraph to "I'm at the Foot of the Ladder . . ." (July 1989). The paragraph states that twenty-seven men have been to the Moon. The actual number is twenty-four, because three men went there twice. These lucky astronauts were James Lovell (*Apollo 8* and *13*), John Young (*Apollo 10* and *16*), and Gene Cernan (*Apollo 10* and *17*). — *Nathan Bridges, Boulder, Colorado*

Where's Neil?

I greatly enjoyed the July 1989 issue of ASTRONOMY. I do have one question. I couldn't help noticing that there was not

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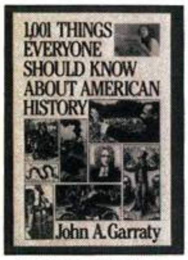
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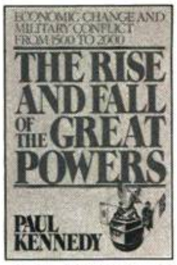
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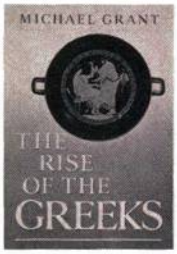
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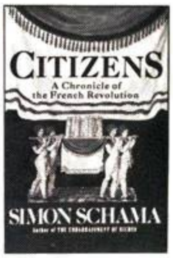
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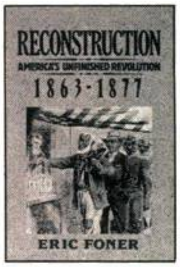
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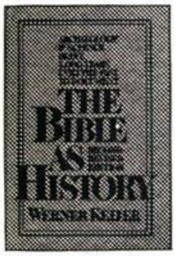
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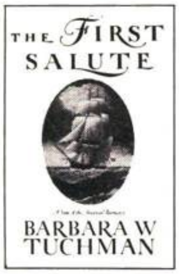
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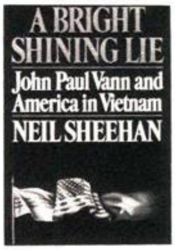
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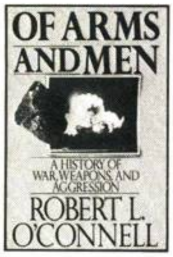
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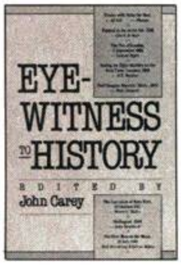
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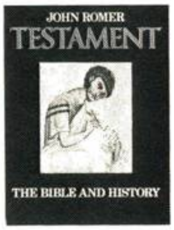
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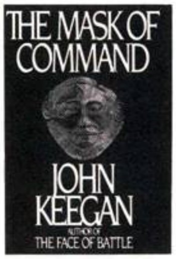
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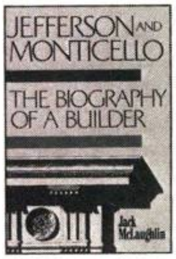
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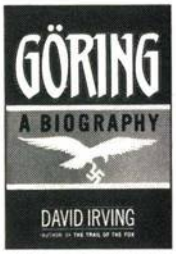
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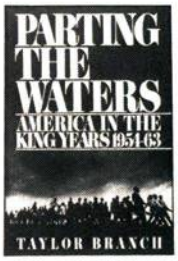
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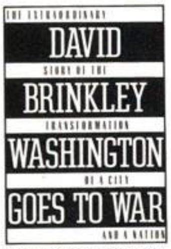
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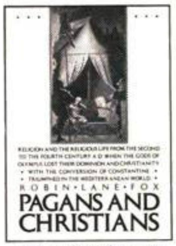
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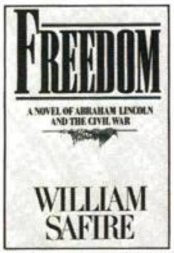
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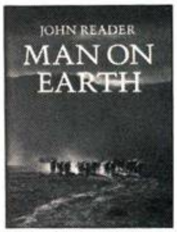
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one photograph of Neil Armstrong. Does he or NASA have copyright protections on pictures of him? I find it strange that the first man on the Moon, the first step on the Moon, was not represented in the article. — *Richard J. Klatt, Big Bend, Wisconsin*

— Neil Armstrong manned the camera for most of the Apollo 11 *mission, thus the proliferation of snapshots of Buzz Aldrin and the lack of pictures of Armstrong. The number of photographs of Armstrong available to publish is limited. Buzz got the best photo opportunities, but Neil did get to take the first step.*

One-Man Observatory

There's more than one way to build an observatory. (See "Build a Backyard Observatory," June 1989.) It isn't necessary to have two or more people to put up a wall. I've done it alone many times on walls at least that big.

After the floor is laid, assemble the studs and plates lying on the floor. Then start several 16-penny nails in the bottom of the plate. Attach two short pieces of board to the edge of the floor to keep the wall from sliding off when you lift it. Then simply lift the wall and drive in the 16-penny nails. It will stand up while you add a brace.

If it is not a windy day, you can attach one piece of the plywood before lifting to square the wall. If it is windy, attach the plywood after raising and bracing the wall.

You can also easily do the roof yourself by building it in place and fastening it temporarily so the casters don't make it roll off in the process.

I also don't see any need for massive 6x6 posts on a small building. In fact, why use any posts? The studs and plywood make a rigid wall by themselves. Just set the building on short posts sticking a foot out of the ground. Use either 4x4s or 6x6s cut to length. Fasten the building to the posts with sheet metal straps to keep it from blowing away in a storm. — *Robert D. Smith, Swisher, Iowa*

Correction

The credit for the photograph on page 50 of the August 1989 issue should be to Gregg Tubbs, Astronaut Memorial Space Center, Cocoa, Florida.

ASTRONOMY welcomes comments, suggestions, corrections, and additional information on articles and astronomy in general. Send your letters to: ASTRONOMY Letters, P.O. Box 1612, Waukesha, WI 53187. Letters may be edited for length or clarity.

Viewpoint

WHO GETS THE CREDIT?

by David Levy
Comet discoverer and research assistant at the University of Arizona's Lunar and Planetary Laboratory

Periodic comet Stephan-Oterma was discovered in 1867 by eighteen-year-old Jerome Coggia, who had just been hired to assist with observations at Marseilles Observatory. Traditionally, credit for a comet discovery had gone to the first person to spot it. However, someone decided that it wouldn't do to name the comet after a youngster whose fortuitous hiring led to the discovery, and so the honor went to the observatory's director, Edouard Stephan, whose only connection with the comet was to measure its precise position after the discovery.

Who is the discoverer in an era when research is carried out by teams?

Young Coggia was clearly wronged. Or was he? Who gets the credit for a major astronomical discovery is often not a simple matter. When the discovery depends on a special environment created by a senior member of a team, an argument can be made that the person who happens to be at the telescope at the right time does not deserve the bulk of the credit. Instead, the person who created the environment should get it.

Who deserves credit for the discovery of pulsars, for example. In 1965, graduate student Jocelyn Bell joined Anthony Hewish in a study of radio galaxies to find quasars. She reduced and examined all the data taken by the radio telescope and within a few weeks had found a puzzling piece of data. At first suspecting a flare star, Hewish installed a better recorder and soon after Bell noticed that whatever it was they had found was pulsing at an extremely regular rate.

After evaluating several possibilities, Hewish announced that the source was a previously undetected kind of star and a year later pulsars were revealed to be neutron stars. Hewish consequently received credit for the discovery.

This case was different than that of Comet Stephan-Oterma. Coggia had been hired to assist in observatory work and discovered a comet independently, but Bell joined a research team whose work, though not specifically looking for pulsars, was searching for discrete radio sources. The program had been carefully planned by Hewish, but Bell, an enthusiastic graduate student, had done much of the work. It was wrong that Bell was not given credit until many years after the discovery, but in this case she was part of a group and would not have made the discovery without it.

Credit for basic data gathering also frequently goes unrecognized in astronomy. I once spent thirty-one nights at an observatory collecting photometric observations for a professor and received no acknowledgement when the data was published. Frankly, the credit for those nights didn't mean a whole lot to me, but if I had been a graduate student at the time, receiving credit for that work could have been valuable to my career.

In most cases, important research cannot be done by one person. So when discoveries are made, the whole team should get the credit, with most of it going to those who did the most work. The principal investigator naturally feels most responsible for the result of any observing program. After all, it was he or she that applied to a telescope allocation committee for observing time, won funding for the project, and spent years developing the program hardware.

With this rationale, the principal investigator could take the credit for himself. But many do not. Observing assistance is frequently credited either in the acknowledgements of the published paper or even as coauthor of the paper.

Fortunately, this situation is largely self-correcting. The person who treats help appropriately gets paid back by attracting the best assistants; the researcher who doesn't will lose assistants, even if he or she is the only one in town with a CCD.

I once heard about an observer who was about to start on a two-week observing run. At the last minute he was asked by another astronomer to take photometric data on a particular object each night during his run. The weather was fine and the observer returned first-class data to the second astronomer. About a year later, a paper came out of that data. Even though the astronomer had never come within half a continent of the observatory, he took all the credit for himself.

I asked the observer what he did. "Nothing. That's just the way this game is played. But no matter how easy it may be, even if my telescope is right on his object, I will never take data for him again."

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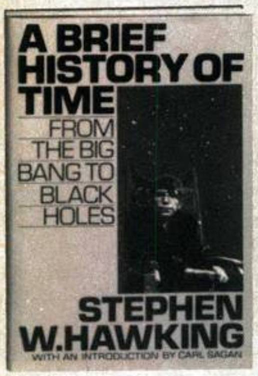
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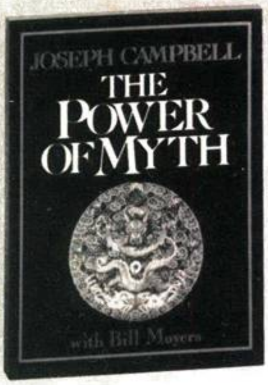
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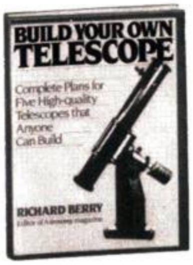
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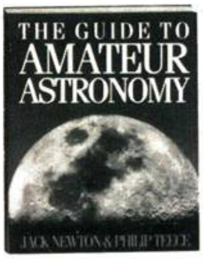
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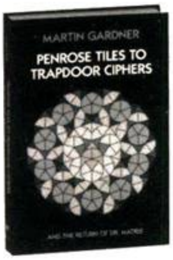
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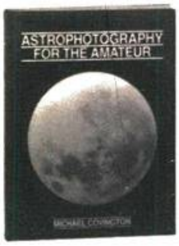
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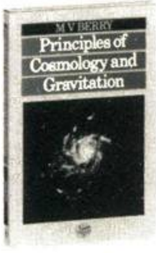
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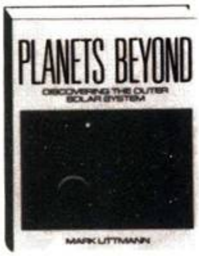
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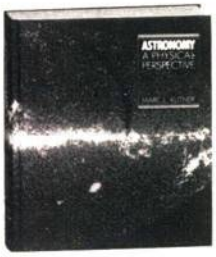
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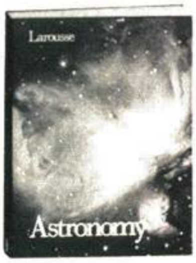
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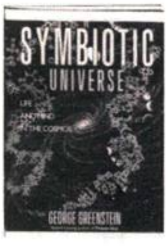
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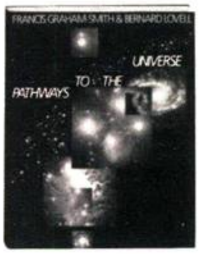
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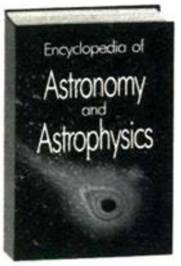
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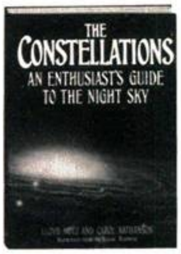
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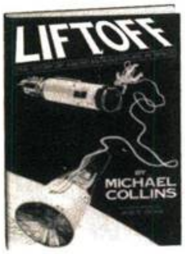
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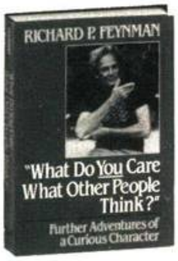
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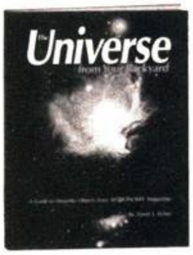
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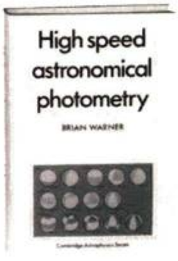
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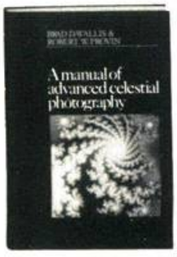
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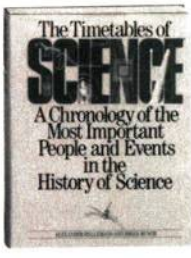
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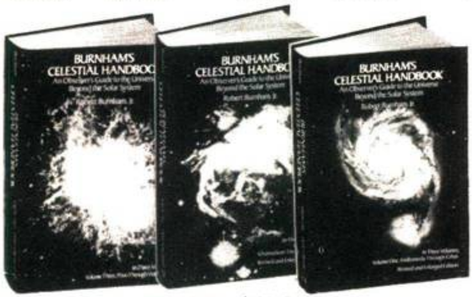
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VIRGO CLUSTER DISTANCE REFINED

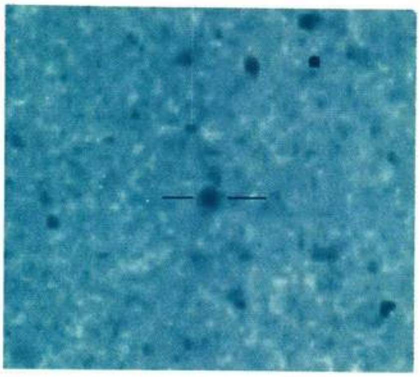
Two teams of astronomers working independently have derived similar distance estimates to selected bright members of the Virgo cluster, the nearest large cluster of galaxies. The two groups used totally different techniques: One involves evaluating the degree of mottling of electronic images of elliptical galaxies, and the other uses the brightest planetary nebulae in other galaxies. The results, presented during last summer's meeting of the American Astronomical Society, agree to within about 10 percent.

In recent years, most distance-estimating techniques have yielded distances to the nearest galaxies that do not differ too greatly. It is only when astronomers extend their various scales beyond the Local Group that the differences snowball to the point that toward the "edge" of the visible universe the differences amount to a factor of two.

Getting an accurate distance value for the Virgo Cluster is important because it provides a firm footing from which the distances to more remote galaxies can be derived. Once the distance to Virgo is nailed down, the brightest members of that cluster can then be used as "standard candles" to compare with the brightest members of more distant galaxy clusters.

The technique used by MIT astronomers Edward Ajhar, G. A. Luppino, and John Tonry is based on a simple premise: the degree of "roughness" of a galaxy's image rendered by a charge-coupled device (CCD) is inversely proportional to its distance. (See "How Far to the Galaxies" by Vincent Kiernan, June 1989.) The amount of image roughness (amplitude) is caused by the number of stars per pixel. Because of their proximity to our Galaxy, the stars in nearby galaxies are easier to resolve than those in more remote galaxies, thus CCD images of nearby galaxies appear mottled while more distant galaxies appear smooth. Galaxies that have the same apparent diameters but lie at disparate distances are revealed by the amplitude of the roughness per pixel.

The MIT group measured the amount of mottling in the images of fifteen galaxies, two in the nearby Leo Group and thirteen in the Virgo Cluster. The distance to the elliptical galaxy M32, whose distance has been firmly established, was used as a calibrator. The results give an average distance to the Virgo Cluster of about 16 megaparsecs (about 52 million light-years).



PLANETARY NEBULAE IN M87, like this one, may help establish the distance to the Virgo Cluster.

The technique looks viable at least out to about 20 megaparsecs (64 million light-years), well within reach of the Virgo Cluster. "We still have a lot to learn, though," said Ajhar. "But once we understand the role total [galaxy] luminosity and stellar populations have in this method, we think it will be very promising as a distance estimation technique."

According to Luppino, one of the most promising aspects of the measurements is that "we agree with the planetary nebula guys. These two methods are as different as they can possibly be and yet we are coming up with the same answers. That's very encouraging."

Equally pleased with the double-barreled results are members of the other team, George Jacoby and Robin Ciardullo of Kitt Peak National Observatory and Holland Ford of the Space Telescope Science Institute. Their technique is based on the fact that the brightest extragalactic planetary nebulae cut off at the same absolute magnitude, about −4.4. Such an upper magnitude cutoff implies that the brightest planetaries have similar brightnesses in all galaxies. This makes them a dependable standard candle, because if you know an object's true brightness, you can estimate its distance from its apparent brightness.

For the Virgo study, Jacoby and his colleagues searched several prominent elliptical galaxies, including M86, M87, and M49 (galaxies that were also studied by the MIT group). They typically identified fifty to one hundred planetaries per galaxy. Their preliminary results indicate that the distance to the Virgo Cluster is about 15 megaparsecs (48 million light-years) and certainly no farther than 20 megaparsecs (64 million light-years).

In the ten years that they have conducted the study, Jacoby, Ciardullo, and Ford have identified some two thousand planetary nebulae in nearby galaxies, including M31, M32, and M81 (see AstroNews, December 1988). Their technique involves using special narrow-band filters to separate the spectral features specific to planetary nebulae (the light of doubly ionized oxygen at about 5007 angstroms) from those of stars and ionized hydrogen.

The team is currently surveying galaxies in Fornax and other galaxy clusters. The results from this observing run, said Ciardullo, "will be a pretty good test" of the reliability of this technique. Although the results are not claimed to be definitive, the congruence of the two techniques nevertheless goes a long way toward establishing the distance to the Virgo Cluster, a long-time goal of astronomers.

MANSON, IOWA: WHERE THE 'BIG ONE' STRUCK?

Perhaps the most sought-after meteorite crater on Earth is the one left by the asteroid or comet that many scientists think struck 65 million years ago. This hypothetical impact is thought to have showered death and extinction on many forms of life around the world, thus drawing a boundary between the Cretaceous and Tertiary geological periods.

No specific crater has yet been identified as the culprit, but four U. S. Geological Survey scientists (M. J. Kunk, G. A. Izett, R. A. Haugerud, and J. F. Sutter) have published a report in *Science* that points toward a crater in northwestern Iowa that lies buried under 100 to 300 feet of more recent deposits. The scientists' work used argon isotopes to date the crater to 65.7 million years ago with an uncertainty of a million years. This places the crater squarely at the geological boundary.

The crater is called the "Manson impact structure" after a nearby town. It has a diameter of about twenty miles and is the largest known impact crater in the United States. No sign of it is visible at the surface, however, and the crater has been discovered, mapped, and studied solely through well borings.

Besides its age, another piece of evidence implicates the Manson structure. The basement rock at the site is gneiss and granite — both possible sources for the shocked quartz grains found worldwide in the boundary layer deposits.

However, magnetic evidence points against Manson being the impact site. The rocks of the uplifted central core of the crater do not have the magnetic orientation they ought to have if the impact occurred 65 million years ago. But Kunk and the team reply that the magnetic history of the rocks isn't clear, and they may have been reoriented after the impact.

A second objection is that Manson is only twenty miles across, whereas most estimates of the Cretaceous-Tertiary impact have called for a crater more than fifty miles in diameter. The scientists respond to this by saying the modeling of the hypothetical impact depends too much on yet-unproven assumptions for the discrepancy to be fatal to the theory. Besides, they note, there may not have been just a single impact, but a closely timed sequence of impacts over much of the world.

Kunk and coworkers conclude that the type and distribution of shocked grains strongly indicate an impact site in the continental interior of western North America, and the nature of the rocks at the Manson site agrees with what is known or guessed about the hypothetical impact. Manson, they say, is a good candidate for a Cretaceous-Tertiary impact, but they also intend to examine closely other impact sites with dates at or near the geological period boundary.

NEW IMPACT EVIDENCE: AMINO ACIDS FROM SPACE

In the last ten years the hypothesis that an asteroid or comet struck Earth at the boundary between the Cretaceous and Tertiary periods 65 million years ago has gone from being a far-out fantasy to becoming the predominant theory to explain the extinction of the dinosaurs and many other kinds of life. Yet there are many scientists, most of them paleontologists, who have objections to the hypothesis. The paleontologists have based their stand on the fossil record, which when examined in detail shows that some extinctions appear to have begun before the impact layer.

Nonetheless, the past decade has seen an impressive array of physical evidence supporting the impact hypothesis. Besides unusual quantities of meteoritic iridium, scientists have found highly shocked quartz grains, soot from massive forest fires, and sedimentary layers that appear to have been jumbled by a gigantic tidal wave.

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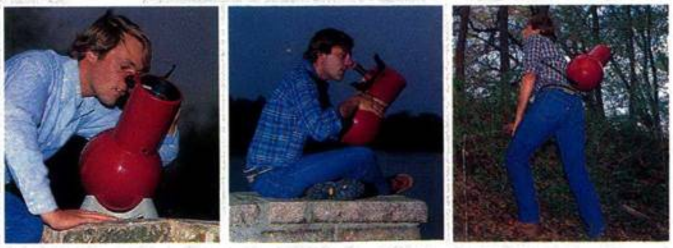

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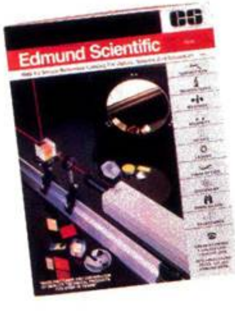

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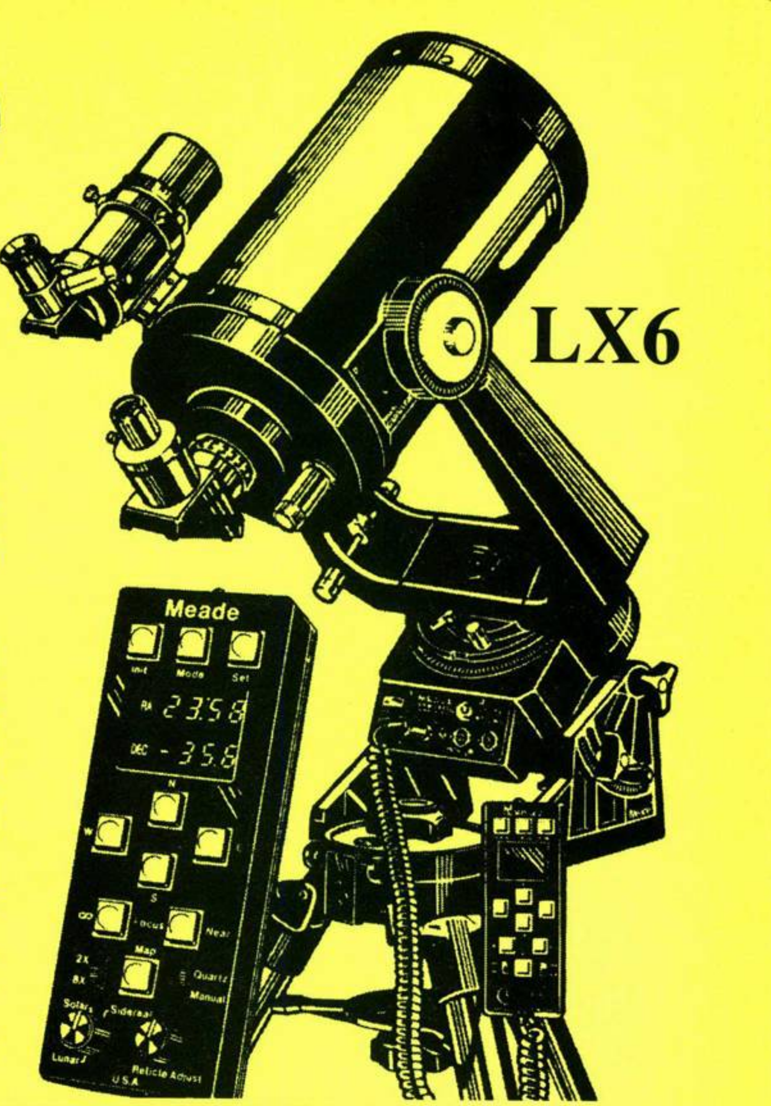

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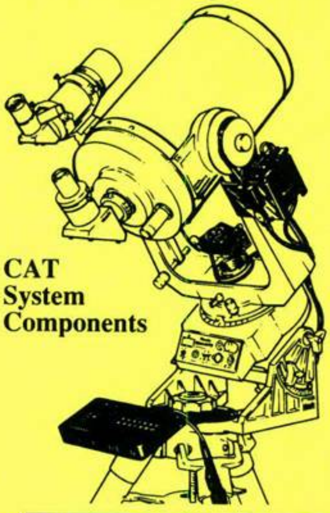
Complete *f*/6.3 telescope tube assembly (8" or 10" aperture, 1,280mm or 1,600mm focal length), with certified diffraction-limited optical system; MCOG ("Multi-Coated Optics Group"), consisting of multi-layer anti-reflection coatings on corrector plate and enhanced reflectivity mirrors; ultra-smooth anti-backlash focus mechanism; giant 9x60mm illuminated-reticle polar-alignment viewfinder with quick-disconnect mounting bracket; 2.00" mirror-type star diagonal, with 1/10 wave multi-coated mirror and adapter for 1.25" eyepieces; Series 4000 26mm Super Plossl eyepiece, 1.25" (49x or 62x); rugged dual-fork astronomical mount with graduated setting circles, manual positioning controls and clutches on both axes of motion; digital quartz-locked, micro-computer-controlled, electronic sidereal-rate pulse-motor drive system and ultra-precision "LX" worm-drive gearing built into telescope drive base; Power Control Panel (also built into drive base) with controls, indicators and connectors for various accessory and auxiliary electronic equipment; Electronic Command Center hand-control unit (note: Meade's Digital Readout System is an ***optional*** accessory); 115Vac/60Hz power adapter with 25 ft. cord; DC battery-pack *(batteries not included)* with 4 ft. cord; 25 ft. DC power cord with automobile cigarette-lighter plug; Deluxe Equatorial Wedge with micrometric adjusters for latitude and azimuth, latitude scale, bubble level and magnetic compass; ultra-rigid adjustable-height Field Tripod; dust covers for optical apertures; foam-lined carrying case for scope-tube/fork-mount/drive-base assembly; instruction manual; limited lifetime warranty.

2080 LX6	(List: $ 4,400)	CALL
2120 LX6	(List: $ 6,400)	CALL
Optional Digital Readout System:		
Mod. 9068, *for* 2080 LX6	(List: $ 590)	CALL
Mod. 9070, *for* 2120 LX6	(List: $ 590)	CALL
Package: Telescope *and* Optional Digital Readout System, together:		
2080 LX6 *with* Mod. 9068	(List: $4,990)	CALL
2120 LX6 *with* Mod. 9070	(List: $6,990)	CALL

FREE FREIGHT! (UPS Ground) for the LX6's shown above

Meade's Computer-Aided Telescope System

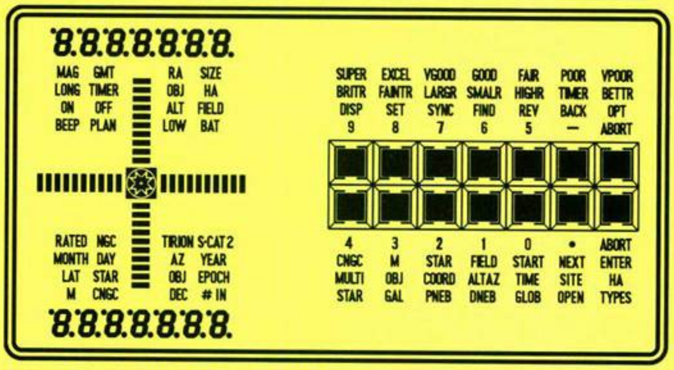


CAT System Components

Meade's **C**omputer-**A**ided **T**elescope (the "CAT") system has most of the advantages of a computer-controlled telescope at only a fraction of the cost. Consisting of a specially-designed, high-speed, extremely powerful computer, along with a pair of high-resolution incremental shaft encoders and their associated mounting hardware, drive components and cabling (*see general arrangement drawing at left, and panel layout drawing at right*), the CAT can readily and quickly direct you to any of the thousands of celestial objects whose coordinates and other descriptive information are permanently stored in its 1Mb plug-in EPROM database, ***including all of the planets***, as well as to any other celestial object of known coordinates (comets, asteroids, quasars, super-novae, etc.). The computer is loaded with extra features and functionality as the panel legends, at right, indicate.

For the computer-literate, there is also a version of the CAT available with an RS-232C port (the "CAT-COM") for connection to a "PC" compatible personal computer. CAT-COM includes four "demonstration" software subroutines, written in BASIC, to show you how to address and control the CAT from your own computer, as well as the necessary RS-232C interconnect cable. The software is supplied on a 5.25" 360Kby diskette, with backup source-code listings in the instruction manual.

The CAT is available for most fork-mounted Schmidt-Cassegrain telescopes, but has been ***electronically integrated*** with the new LX6 series, so that the encoders and the CAT computer plug directly into the drive-base. Consequently, during our introduction of the LX6 series telescopes, we are offering extra savings on packages consisting of an LX6 telescope and one or the other of the CAT systems.



Optional Computer-Aided Telescope (CAT) System:		
CAT *for* 2080 *or* 2120 LX6	(List: $1,990)	CALL
CAT-COM *for* 2080 *or* 2120 LX6	(List: $2,290)	CALL
Package: Telescope *and* Optional CAT System, together:		
2080 LX6 *with* CAT	(List: $6,390)	CALL
2080 LX6 *with* CAT-COM	(List: $6,690)	CALL
2120 LX6 *with* CAT	(List: $8,390)	CALL
2120 LX6 *with* CAT-COM	(List: $8,690)	CALL
Hardcopy Listing of CAT Database	(List: $ 60)	CALL

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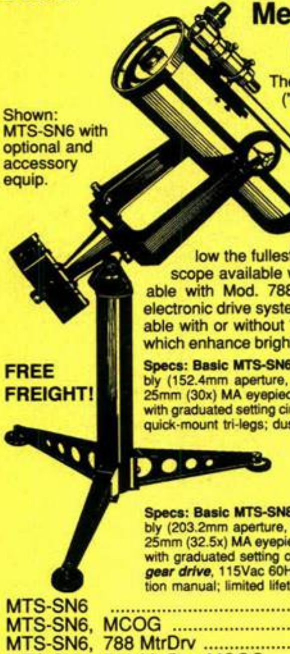

Shown: MTS-SN6 with optional and accessory equip.

FREE FREIGHT!

These scopes' wide, bright, highly corrected fields of view ("rich"-fields) and "fast" focal ratios make them ideal for both deep space visual observing and prime focus astrophotography. Easy and convenient to transport and use because of their "fork" -type equatorial mounts, they are excellent all-around scopes for those just starting in astronomy, as well as for experienced astrophotographers. Their 1.25"/2.00" focusers not only permit the use of the greatest variety of eyepieces, but also allow the fullest illumination of the film-plane during photography. 6" scope available with or without Mod. 788 motor drive. 8" scope available with Mod. 788 motor drive, or "LX3" quartz-synchronized micro-electronic drive system for maximum accuracy and precision. All are available with or without "MCOG" (multi-coated optics group) optical coatings, which enhance brightness and contrast of visual and photographic images.

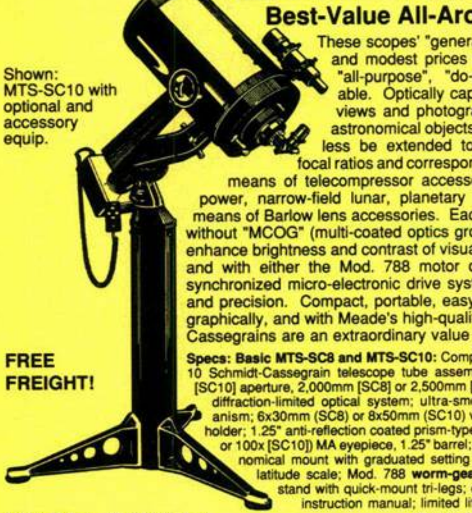
Specs: Basic MTS-SN6: Complete 6"A, f/5 Schmidt-Newtonian telescope tube assembly (152.4mm aperture, 762mm focal length); 2" helicoid focuser, with 1.25" adapter; 25mm (30x) MA eyepiece, 1.25" barrel; rugged dual-fork equatorial astronomical mount with graduated setting circles, latitude adjustment, and latitude scale; pipe-pier stand with quick-mount tri-legs; dust cover; instruction manual; limited lifetime warranty.

Ask about our special finderscope & barlow Accessory Packages for these MTS Schmidt-Newtonians

Specs: Basic MTS-SN8: Complete 8"A, f/4 Schmidt-Newtonian telescope tube assembly (203.2mm aperture, 812.8mm focal length); 2" helicoid focuser, with 1.25" adapter; 25mm (32.5x) MA eyepiece, 1.25" barrel; rugged dual-fork equatorial astronomical mount with graduated setting circles, latitude adjustment, and latitude scale; Mod. 788 ***worm-gear drive***, 115Vac 60Hz; pipe-pier stand with quick-mount tri-legs; dust cover; instruction manual; limited lifetime warranty.

MTS-SN6	(List: $ 1,050)	CALL
MTS-SN6, MCOG	(List: $ 1,130)	CALL
MTS-SN6, 788 MtrDrv	(List: $ 1,200)	CALL
MTS-SN6, 788 MtrDrv, MCOG	(List: $ 1,280)	CALL
MTS-SN8, 788 MtrDrv	(List: $ 1,500)	CALL
MTS-SN8, 788 MtrDrv, MCOG	(List: $ 1,590)	CALL
MTS-SN8, LX3 MtrDrv	(List: $ 1,800)	CALL
MTS-SN8, LX3 MtrDrv, MCOG	(List: $ 1,890)	CALL

Meade's MTS Schmidt-Cassegrains
Best-Value All-Around Performers!


Shown: MTS-SC10 with optional and accessory equip.

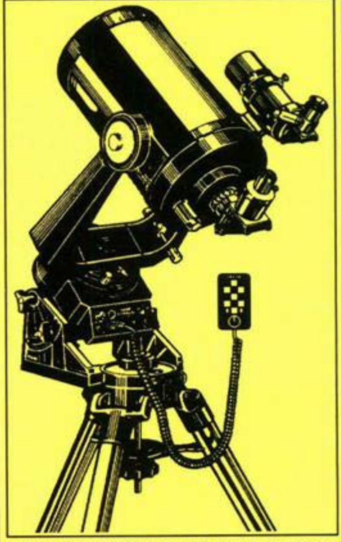
FREE FREIGHT!

These scopes' "general-purpose" f/10 focal ratios and modest prices make them the best-value "all-purpose", "do-everything" scopes available. Optically capable of delivering exquisite views and photographs of almost all types of astronomical objects "as-is", they may nevertheless be extended to extremely "fast" effective focal ratios and correspondingly wide fields of view by means of telecompressor accessories, or to extremely high power, narrow-field lunar, planetary and multiple-star work by means of Barlow lens accessories. Each scope is available with or without "MCOG" (multi-coated optics group) optical coatings, which enhance brightness and contrast of visual and photographic images, and with either the Mod. 788 motor drive, or the "LX3" quartz-synchronized micro-electronic drive system for maximum accuracy and precision. Compact, portable, easy to use visually and photographically, and with Meade's high-quality optics, the MTS Schmidt-Cassegrains are an extraordinary value in astronomical telescopes.

Specs: Basic MTS-SC8 and MTS-SC10: Complete 8"A (SC8) or 10"A (SC10) f/10 Schmidt-Cassegrain telescope tube assembly (203.2mm [SC8] or 254mm [SC10] aperture, 2,000mm [SC8] or 2,500mm [SC10] focal length), with certified diffraction-limited optical system; ultra-smooth anti-backlash focus mechanism; 6x30mm (SC8) or 8x50mm (SC10) viewfinder; 1.25" visual accessory holder; 1.25" anti-reflection coated prism-type star diagonal; 25mm (80x [SC8] or 100x [SC10]) MA eyepiece, 1.25" barrel; rugged dual-fork equatorial astronomical mount with graduated setting circles, latitude adjustment; and latitude scale; Mod. 788 **worm-gear drive**, 115Vac 60Hz; pipe-pier stand with quick-mount tri-legs; dust covers for optical apertures; instruction manual; limited lifetime warranty.

MTS-SC8, 788 MtrDrv	(List: $ 1,800)	CALL
MTS-SC8, 788 MtrDrv, MCOG	(List: $ 1,890)	CALL
MTS-SC8, LX3 MtrDrv	(List: $ 2,150)	CALL
MTS-SC8, LX3 MtrDrv, MCOG	(List: $ 2,240)	CALL
MTS-SC10, 788 MtrDrv	(List: $ 2,780)	CALL
MTS-SC10, 788 MtrDrv, MCOG	(List: $ 2,950)	CALL
MTS-SC10, LX3 MtrDrv	(List: $ 3,180)	CALL
MTS-SC10, LX3 MtrDrv, MCOG	(List: $ 3,350)	CALL

Meade's LX5's



Fully equal to LX6's in terms of their standard equipment, they come complete with quartz-lock microelectronic pulse motor drive, sophisticated hand control unit with photographic drive correction functions built-in, 2.00" star diagonal for advanced, premium-grade eyepieces, & giant 9x60mm finderscope!

Specs: 2080/LX5 and 2120/LX5: Complete 8"A (2080/LX5) or 10"A (2120/LX5) f/10 Schmidt-Cassegrain telescope tube assembly (203.2mm or 254mm aperture, 2,000mm or 2,500mm focal length), with certified diffraction-limited optical system; MCOG ("Multi-Coated Optics Group"), consisting of multi-layer anti-reflection coatings on corrector plate and enhanced reflectivity mirrors; ultra-smooth anti-backlash focus mechanism; giant 9x60mm illuminated-reticle polar-alignment viewfinder with quick-disconnect mounting bracket; 2.00" mirror-type star diagonal, with 1/10 wave multi-coated mirror and adapter for 1.25" eyepieces; Series 4000 26mm Super Plossl eyepiece, 1.25" (77x or 96x); rugged dual-fork astronomical mount with graduated setting circles, manual positioning controls and clutches on both axes of motion; digital quartz micro-electronic sidereal-rate pulse-motor drive system and ultra-precision "LX" worm-drive gearing built into telescope drive base; Power Control Panel (also built into drive base) with controls, indicators and connectors for various accessory and auxiliary electronic equipment; Electronic Command Center hand-control unit; 115Vac 60Hz AC power adapter with 25 ft. cord; DC battery-pack *(batteries not included)* with 4 ft. cord; 25 ft. DC power cord with automobile cigarette-lighter plug; Deluxe Equatorial Wedge with micrometric adjusters for latitude and azimuth (polar-alignment adjustments), latitude scale, bubble level, magnetic compass (and no-tool knob set on 8" scope only); ultra-rigid adjustable-height Field Tripod; dust covers for optical apertures; foam-lined carrying case for scope-tube/fork-mount/drive-base assembly; audio cassette instructions; instruction manual; limited lifetime warranty.

2080/LX5, MCOG, Wedge, Tripod (as above)	(List: $ 3,800)	CALL
2120/LX5, MCOG, Wedge, Tripod (as above)	(List: $ 5,400)	CALL

FREE FREIGHT! (UPS Ground) for the LX5's above

Meade's LX3's - Still Going STRONG!

Specs: 2080/LX3 and 2120/LX3: Complete 8"A (2080/LX3) or 10"A (2120/LX3) f/10 Schmidt-Cassegrain telescope tube assembly (203.2mm or 254mm aperture, 2,000mm or 2,500mm focal length), with certified diffraction-limited optical system; MCOG ("Multi-Coated Optics Group"), consisting of multi-layer anti-reflection coatings on corrector plate and enhanced reflectivity (multi-layer over-coated) mirrors; ultra-smooth anti-backlash focus mechanism; large 8x50mm viewfinder; 1.25" visual back (eyepiece holder); 1.25" prism-type star diagonal, anti-reflection coated; 25mm (80x or 100x) MA eyepiece, 1.25" barrel; rugged dual-fork astronomical mount with graduated setting circles, manual positioning controls and clutches on both axes of motion; quartz micro-electronic sidereal-rate drive system and ultra-precision "LX" worm-drive gearing built into telescope drive base; Power Control Panel (also built into drive base) with controls, indicators and connectors for various accessory and auxiliary electronic equipment; Electronic Command Center hand-control unit **(10" 2120/LX3 only)**; 115Vac 60Hz AC power adapter with 25 ft. cord; 25 ft. DC power cord w/cigarette-lighter plug; Deluxe Equatorial Wedge with micrometric adjusters for latitude and azimuth (polar-alignment adjustments), latitude scale, bubble level and magnetic compass (and no-tool knob set on 8" scope only); ultra-rigid adjustable-height Field Tripod; dust covers for optical apertures; foam-lined carrying case for scope-tube/fork-mount/drive-base assembly; instruction manual; limited lifetime warranty.

2080/LX3, MCOG, Wedge, Tripod (as above)	(List: $ 3,520)	CALL
2120/LX3, MCOG, Wedge, Tripod (as above)	(List: $ 5,200)	CALL

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Meade's Advanced Electronic Systems
The COMPUTER-AIDED TELESCOPE System
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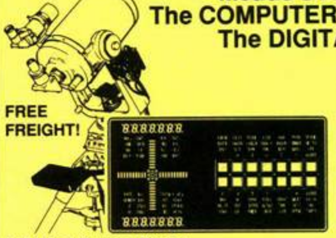

FREE FREIGHT!

Meade's "CAT" and "DSC" Systems enhance your ***observing*** pleasure by virtually eliminating the difficulties of "finding". Sophisticated micro-computer technology and software make it possible! The CAT System (at left), contains an internal catalog of over 7,500 astronomical objects. The DSC System provides precise, digital coordinate readout too, but without the internal catalog. Both systems are easy, bolt-on retrofits - no drilling or tapping required. A variant of the CAT ("CAT-COM") can communicate with a PC-type computer (see opposite page for details). Package pricing is available when either System is purchased at the same time as its telescope (not for MTS).

Individual System Pricing:		
DSC Sys., for 2080, 2120, C8 or C11	(List: $ 700)	CALL
CAT Sys., for 2080, 2120, C8 or C11	(List: $ 1,990)	CALL
CAT-COM, for 2080, 2120, C8 or C11	(List: $ 2,290)	CALL
Package Pricing (Electronics System purchased at same time as its telescope):		
DSC Sys., for 2080, 2120, C8 or C11	(List: $ 700)	CALL
CAT Sys., for 2080, 2120, C8 or C11	(List: $ 1,990)	CALL
CAT-COM, for 2080, 2120, C8 or C11	(List: $ 2,290)	CALL

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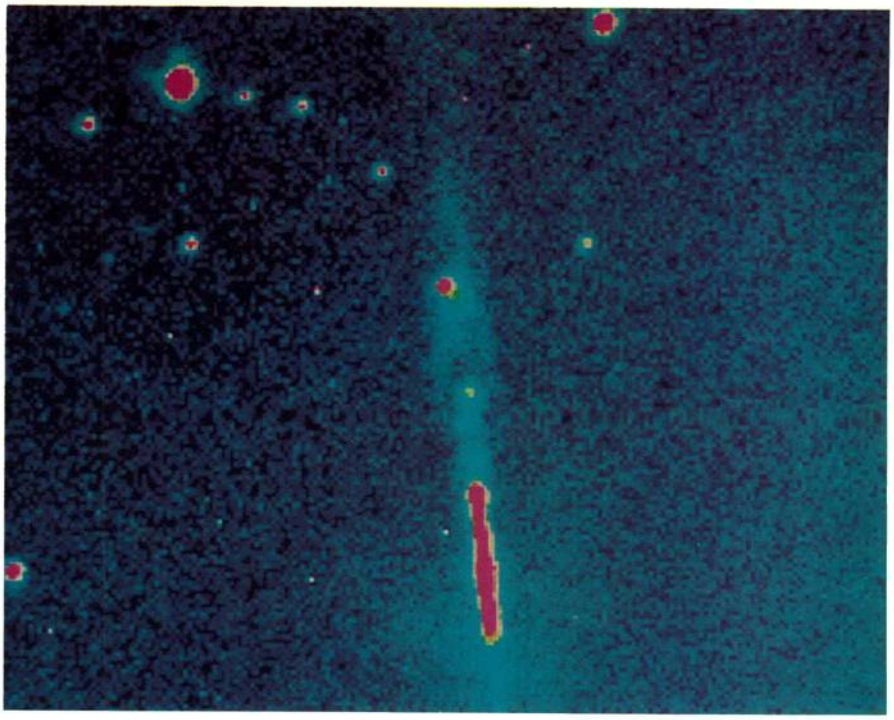
Astronomy AS8902MB.PM3

Writing in *Nature*, Meixun Zhao and Jeffrey Bada of the Scripps Institution of Oceanography report finding enriched quantities of two amino acids in a Danish clay deposit that spans the Cretaceous/Tertiary boundary. Exceedingly rare on Earth, these amino acids (alpha-aminoisobutyric acid and isovaline) are common constituents of carbonaceous chondrite meteorites; the laboratory identification of the amino acids appears to be correct.

Yet as Zhao and Bada point out, there are puzzling aspects to their findings. While iridium, normally used as the telltale tracer for the impact, shows an abrupt "spike" in abundance right at the boundary, the amino acids are almost wholly absent there. Instead, the amino acids become detectable three feet below the boundary, increase up to it, then virtually disappear at it, and become abundant again throughout the first foot of deposits above it.

Bada and Zhao suggest that after the impact, the amino acids could have diffused outward to contaminate the layers above and below. (It is hard otherwise to explain their presence in layers deposited *before* the impact.) But if this process occurred, it still does not solve a second problem, which remains with no good answer so far: Why does the actual impact layer itself have such scant trace of these amino acids in it? Zhao and Bada intend to search for the two amino acids in boundary deposits at other sites and to look for other known extraterrestrial amino acids of which about fifty are known.

STELLAR JET REVEALS VIOLENT STARBIRTH



A POWERFUL JET shoots from the nebular cloud harboring a young, solar-type star. The mushroom-shaped bow shock can be seen in the upper part of the photo. The round objects are background stars in the Milky Way.

An astronomer at the European Southern Observatory has discovered a newborn star that is experiencing the birth events that our Sun experienced over 4.7 billion years ago. Designated HH-111, the star is situated within the Orion interstellar clouds some 1,500 light-years distant and displays an intense, narrow jet.

The discovery was made last spring by Bo Reipurth, who was searching for newborn stars on wide-field photographs taken with the Schmidt telescope at the La Silla Observatory in Chile. Electronic images taken with the Danish 1.5-meter telescope detected the jet emerging from the interstellar cloud in which the newborn star is hidden. Stellar jets are thought to arise from matter raining down on newborn stars; this matter originates from accretion disks of gas and dust left over after the star formed. The jet material flows perpendicularly to the accretion disk, probably along the star's magnetic field lines. This jet is said to be one of the largest and most perfectly shaped stellar jets ever seen.

Spectra indicate that particles in the jet are emerging from a point near the hidden newborn star at a velocity of several hundred miles per second. The particles pile up like cars in a massive traffic jam at the point where they encounter the denser interstellar medium, creating a mushroom-shaped "bow shock." Reipurth estimates that it takes particles one thousand years to travel the total length of the jet, which is estimated to be about 2 light-years.

Based on these observations, Reipurth believes HH-111 is in a crucial starbirth phase, dispersing the cloud of dust and gas surrounding it. In the coming years the jet may show significant structural changes. Monitoring the jet, said Reipurth, will indirectly tell astronomers what is happening with the young star, which in turn may improve our knowledge about the birth of our Sun and the solar system.

25-METER SOVIET TELESCOPE PLANNED FOR 2000

The Soviet Union will soon begin building the world's largest optical telescope. According to Academician Alexander Boyarchuk, chairman of the Soviet Academy of Sciences Astronomical Council, the 25-meter segmented-mirror telescope will make it possible to observe 28th-magnitude objects, extending the range of observation almost to the edge of the visible universe. The telescope is scheduled to be completed in 2000.

The 25-meter instrument will have six times more light collecting area than the U.S. 10-meter Keck Telescope now nearing completion in Hawaii.

The program to build the 25-meter instrument will be conducted at the Crimean Astrophysical Observatory under the guidance of the observatory's director, Nikolai Steshenko. The estimated cost of the project is 350 million roubles —roughly $500 million.

Despite the telescope's very high cost, it will be far less expensive than a relatively small Earth-orbiting telescope. The *Hubble Space Telescope* has cost the United States well over $1 billion.

The new telescope, thanks to its large mirror area, will collect seventeen times as much light as the Zelenchuk 6-meter Bolshoi Altazimuth Telescope. While the practical resolving power of the largest telescopes is often considered 1 arcsecond, developers of the new giant expect to compensate for atmospheric turbulence, improving resolution to between 0.3 and 0.4 arcseconds.

"The combination of the larger mirror and the smaller images means that the 25-meter telescope will bring us more remote and fainter objects down to 28th magnitude," explained Boyarchuk. "Today we can observe celestial bodies

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Like the regular Astro Master,™ the advanced model is a real-time digital readout of right ascension and declination coordinates. Unlike other digital setting circles which require the use of a clock drive, the Advanced Astro Master™ can be used with or without a clock drive. Once aligned, the system keeps track of where it is pointed.

But the Advanced Astro Master™ is more than a digital read-out for celestial coordinates. This instrument will also guide you to any of the more than 8,000 items in its data base. Included is the entire Revised New General Catalog, the Messier catalog and over 400 interesting double and multiple stars.

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- Built-in timer for astrophotography
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- The Advanced Astro Master™ contains the Revised New General Catalog of Non-stellar Objects by Sulentic and Tifft, the entire Messier Catalog and over 400 interesting double and multiple stars.
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no fainter than the 26th magnitude. As a result, there will be practically no zones left in the universe inaccessible to astronomical observation from the Earth. We will be able to investigate the earliest states of the universe's development."

Developers have had to overcome serious technological difficulties in designing the telescope. The 25-meter mirror will consist of three hundred hexagonal segments, each individually zeroed in on an object by a computer system. Such a computer system has already been tested on a 1.2-meter prototype mirror consisting of one central segment and six peripheral segments.

As Boyarchuk observed, international cooperation of specialists may play a great role in the implementation of this large-scale project and the use of the giant telescope. The telescope will belong to the academies of sciences of socialist countries, but this does not preclude participation of interested Western partners. Boyarchuk stressed that Soviet astronomers are interested in collaborating with their colleagues in Australia, Canada, and the United States. — *Mikhail Sigov, Novosti Press Agency*

CARNEGIE SHARES IN PALOMAR TELESCOPE

Under a new agreement between the Carnegie Institution of Washington and the California Institute of Technology, Carnegie astronomers can use 25 percent of the observing nights scheduled on the 200-inch Hale Telescope on Palomar Mountain.

In return for the use of the telescope, Carnegie will contribute operating funds and provide new auxiliary instrumentation for the telescope. Carnegie will share fully in the telescope's use. Its assigned nights will be distributed uniformly throughout the year and at all the phases of the Moon.

Carnegie will also be represented on the Telescope Steering Committee and will advise the observatory director on operations, support, telescope instruments, and changes to the observatory facility. The agreement runs for five years.

Cornell University shares another 25 percent of the Hale telescope's time (see AstroNews, March 1989) through a similar arrangement and is also represented on the Telescope Steering Committee. Caltech owns the telescope.

Caltech and Carnegie have long worked collaboratively in astronomy. From 1948 until 1980, astronomers from both institutions were organized as a single staff.

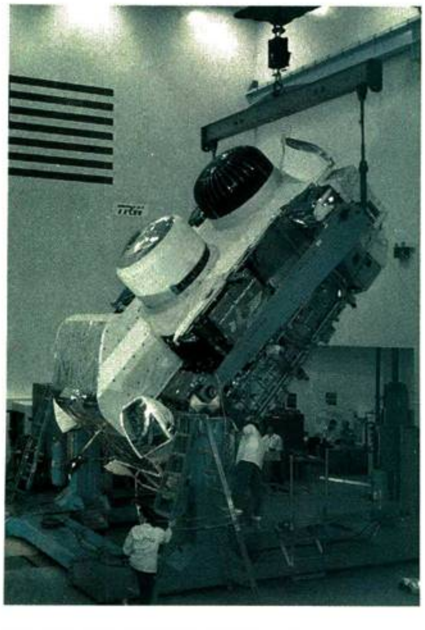
Space News

REACTORS THREATEN SPACE SCIENCE

Until recently the biggest danger posed by spacecraft carrying nuclear reactors in Earth orbit was that they could reenter the atmosphere and spread radioactive debris. This was demonstrated in 1978 when Cosmos 954, a Soviet RORSAT nuclear-powered radar satellite used to track ships at sea, crashed into northern Canada, scattering debris across the frozen tundra.

Now astrophysicists have learned that these nuclear satellites also threaten their ability to make certain astronomical observations from space. Recently declassified reports show that the Department of Defense has known for several years that Soviet RORSATs are interfering with orbiting scientific satellites. In 1980, for example, the gamma-ray spectrometer on the *Solar Maximum Mission* satellite detected gamma-ray emissions that could only have come from the Soviet Cosmos 1176. The Defense Department used readings from *Solar Max* to keep tabs on these Soviet satellites through 1986.

The problem for space scientists now is that a big new gamma-ray instrument —the *Gamma Ray Observatory*, one of NASA's four Great Observatories — is scheduled to go into orbit next June. Scientists are concerned about the impact the orbiting reactors will have on the $450 million observatory's ten-year survey of gamma-ray sources.



DETECTING GAMMA RAYS will be a trickier task for NASA's *Gamma Ray Observatory*, thanks to Soviet nuclear-powered satellites.

The observatory will carry several instruments and sensors, one of which —the Burst and Transient Source Experiment — is particularly susceptible to interference from nearby nuclear reactors. Gamma rays from the unshielded reactors on the Soviet satellites can "load the instrument's computer memory with false events," explained Don Kniffen, GRO project scientist. If this happens, the instrument could miss the short, intense natural gamma-ray bursts that it is designed to monitor.

The presence of orbiting nuclear reactors won't be a disaster for the observatory, but it is a major nuisance. NASA is developing computer software that will predict when a RORSAT is about to pass close to the observatory. When a RORSAT approaches, the experiment will shut down for up to fifteen minutes. This will have little impact on the instrument's data collection ability but will make day-to-day operations more complicated.

The issue of nuclear reactors in space doesn't end with Soviet spy satellites and gamma-ray telescopes, however. Many scientists worry that a large number of nuclear reactors in orbit could eventually make it difficult if not impossible to conduct many types of deep-space research from Earth orbit. The presence of many space nuclear reactors might also endanger astronauts in orbit.

The problem has provided ammunition for organizations like the Federation of American Scientists and The Committee to Bridge the Gap that want to see nuclear reactors banned from outer space altogether, except for those used on deep-space missions such as the *Voyager* probes to the outer solar system. California Representative George E. Brown has introduced legislation to keep nuclear reactors from being launched into space.

At present there are no U.S. nuclear reactors in orbit. However, the Department of Defense is conducting research to develop new space reactors, and there is concern that the Strategic Defense Initiative, if fully implemented, could require hundreds of nuclear reactors in Earth orbit. — *Robert G. Nichols*

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TEXAS STAR PARTY SURVIVES RAIN

Over six hundred amateur astronomers flocked to western Texas between May 29 and June 4, 1989, for the tenth Texas Star Party. Known for its dark skies, the event offers amateurs the best observing they'll experience during the year. This year, however, unstable air over northern Mexico sent thunderstorms cascading over the star party, halting attempts at observing. Instead, amateurs focused on a wide variety of talks, telescopes, and endless socializing.

The inclement weather didn't completely wipe out observing, however. During the first few nights hopes were high and amateurs stuck by their scopes, wrapping the instruments in tarps and retiring inside only when rain began to fall. Some observers managed to peek through the clouds for brief periods, although seeing and transparency were far below par for the Prude Ranch site, located just five miles from McDonald Observatory. The sky remained reasonably clear on Saturday, June 3, the final night of the star party. But by then most attendees were too tired to stay up late or had to leave early the next morning.

This year's invited talks were highlighted by a presentation on Pluto. Richard P. Binzel of the Massachusetts Institute of Technology described the new data astronomers have collected for Pluto and its moon Charon, the results of over two years of observing mutual events between the two bodies. Binzel showed the low resolution surface map that astronomers have pieced together and revealed a new model of Pluto, suggesting its composition is rockier and less icy than was previously thought.

Amateur talks ranged from telescope building to amateur meetings to deep-sky observing. John Cotton of the Texas Astronomical Society of Dallas showed a series of movies made by the club in the 1960s to spoof telescope making. The Super 8 films featured teenagers who ran into telescope troubles, from gooey pitch to policemen who hauled them off to jail when they attempted to observe with completed telescopes. Don Garland of the Noble Planetarium in Fort Worth showed a five-minute videotape he made at last year's TSP. The tape drew "oohs" and "aahs" for its dramatic time-lapse footage of stars speeding across the black sky.

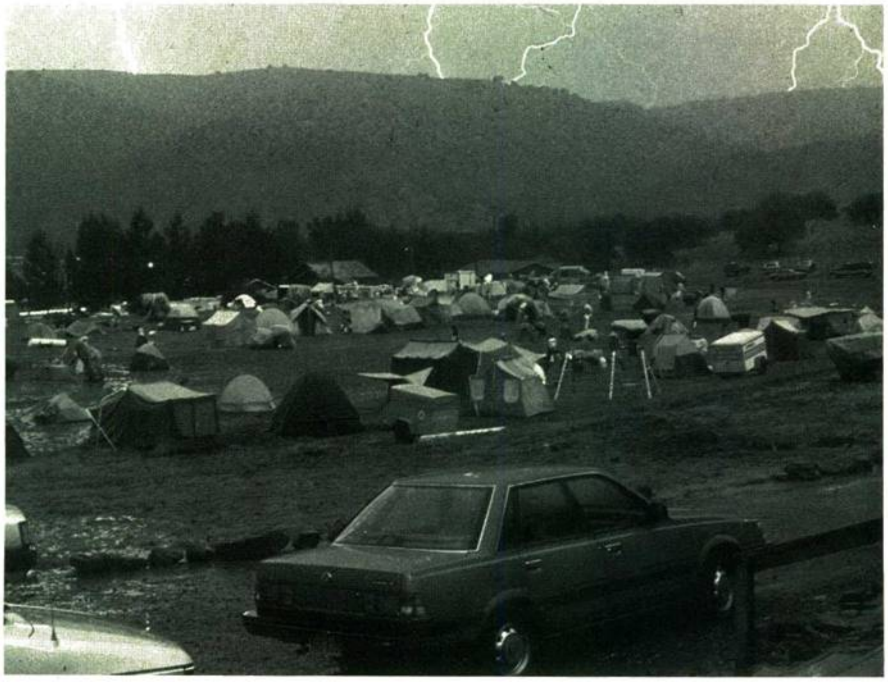
Many of this year's talks had observing as a theme. Joel Harris of Burbank, California, promoted his tour to Baja, California, to see the solar eclipse in 1991. He showed views of the observing areas where tour groups will go and percentage chances for clear weather. Brian Skiff of Lowell Observatory argued that proper dark adaptation is far more critical for good observing than most amateurs suspect, proposing that as little as a few minutes of exposure to bright sunlight can dramatically damage your ability to see faint objects for more than twenty-four hours.

In other observational talks, Roger N. Clark, an avid deep-sky observer from Colorado, described his methods for drawing galaxies and nebulae and stressed the importance of deep-sky observing at high powers. David J. Eicher of *Deep Sky* and ASTRONOMY predicted a bright future for deep-sky observers, one with a continuing expansion of "fallout from the Dobsonian revolution" — better scopes, more and better accessories and films, and increasingly accurate and abundant information on objects.

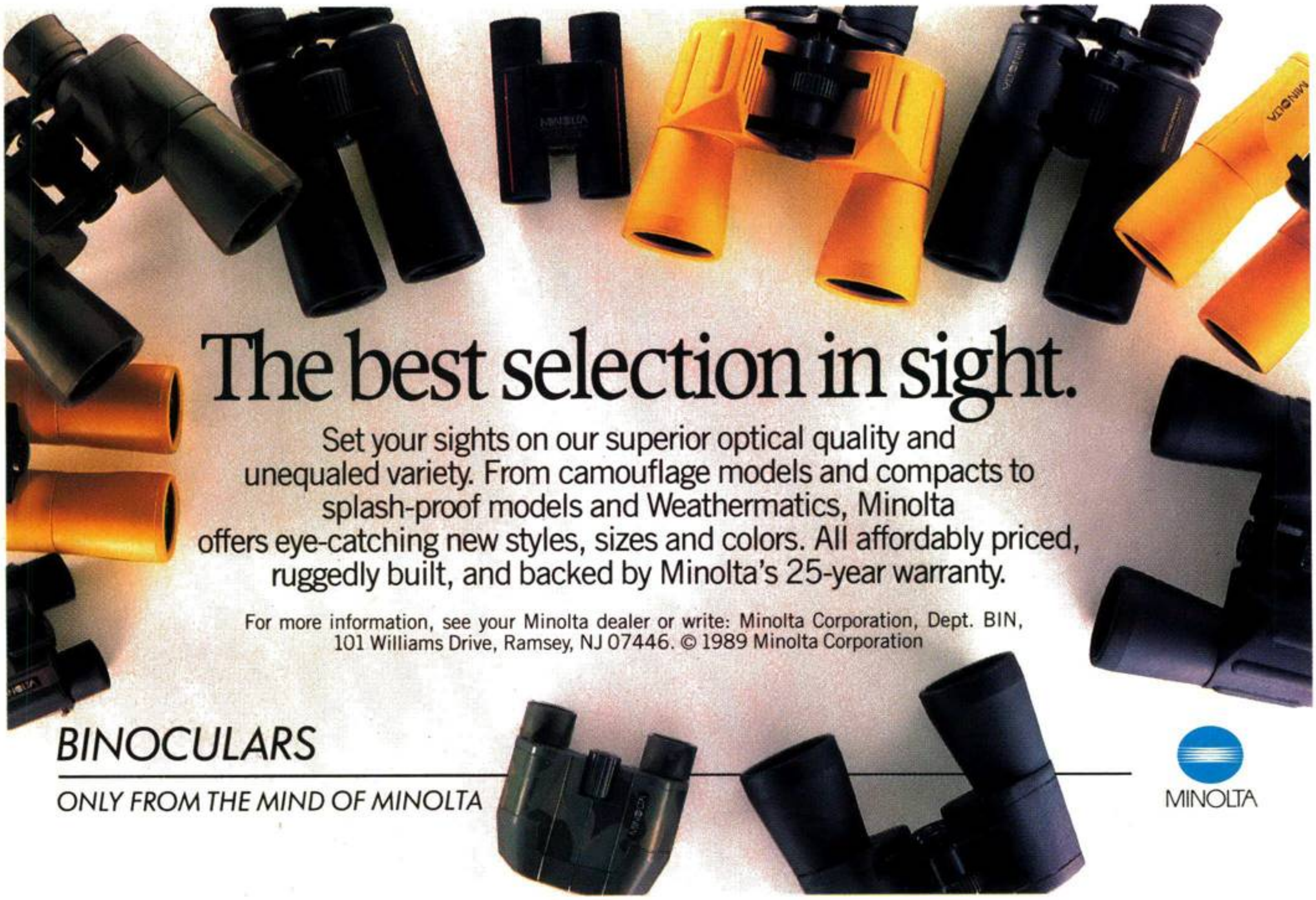
At the Astronomical League council meeting on Saturday, members of the group's Southwest Region celebrated a victory in the war against light pollution. David K. Clark, vice chairman of the region, explained that profits of $10,000 from the Texas Star Party and the League's Southwest Region have been used toward replacing outdoor lights harmful to astronomy in the county that surrounds the Prude Ranch and McDonald Observatory. This has significantly reduced light pollution in the area. All astronomers consider it a major victory not only for Jeff Davis County but for demonstrating the ability of amateur astronomers to stop and reverse the spread of light pollution.

This year's star party culminated with a talk on Saturday night by Donald C. Parker of Coral Gables, Florida. A Mars Recorder for the Association of Lunar and Planetary Observers, Parker summarized the 1988 opposition of Mars and entertained the audience by showing his high-resolution photographs of the Red Planet and its many albedo features. Following Parker's talk the award ceremony to honor telescopes and observers was held.

After the Saturday night gathering, six hundred tired amateur astronomers retired to tents, cabins, and motel rooms, anxious for the next TSP even before the present one was over. ☐



LIGHTNING BOLTS dazzled viewers at the 1989 Texas Star Party. Frequent storms shifted the emphasis from observing to talks. Photo by Trey Mitchell.



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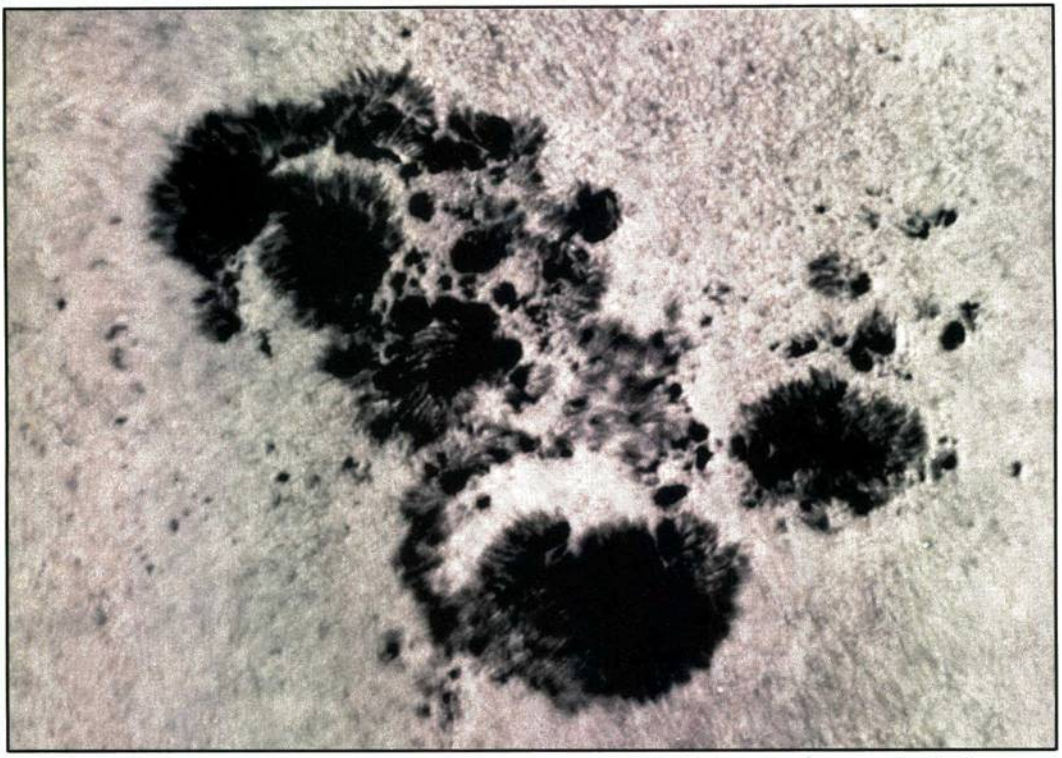
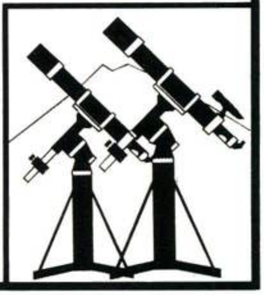


Another incredible photo by Wolfgang Lille of W. Germany. Print resolution is sub-arc second. Unsharp zones are due to heavy turbulence. Photographed July 4, 1988.



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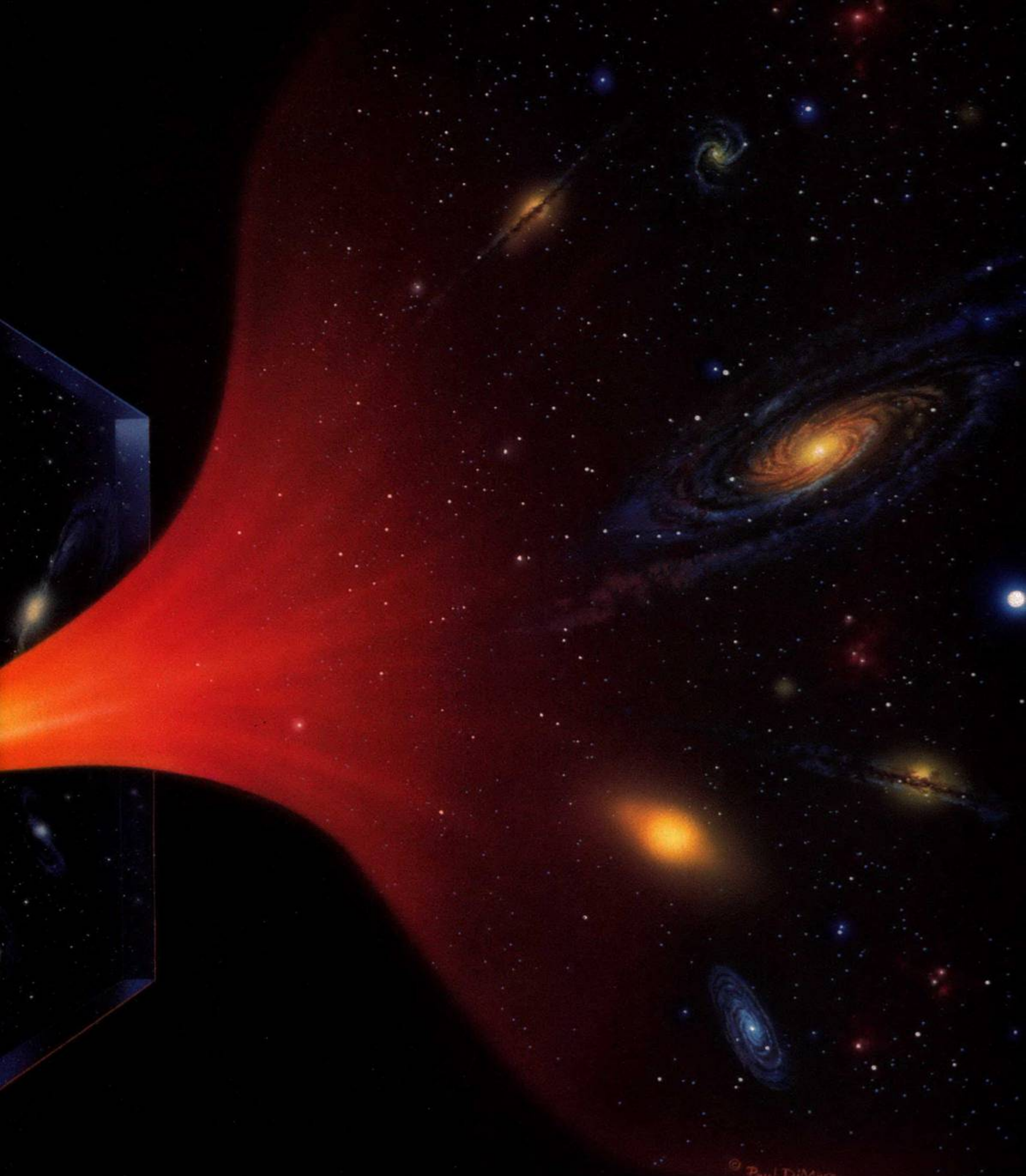
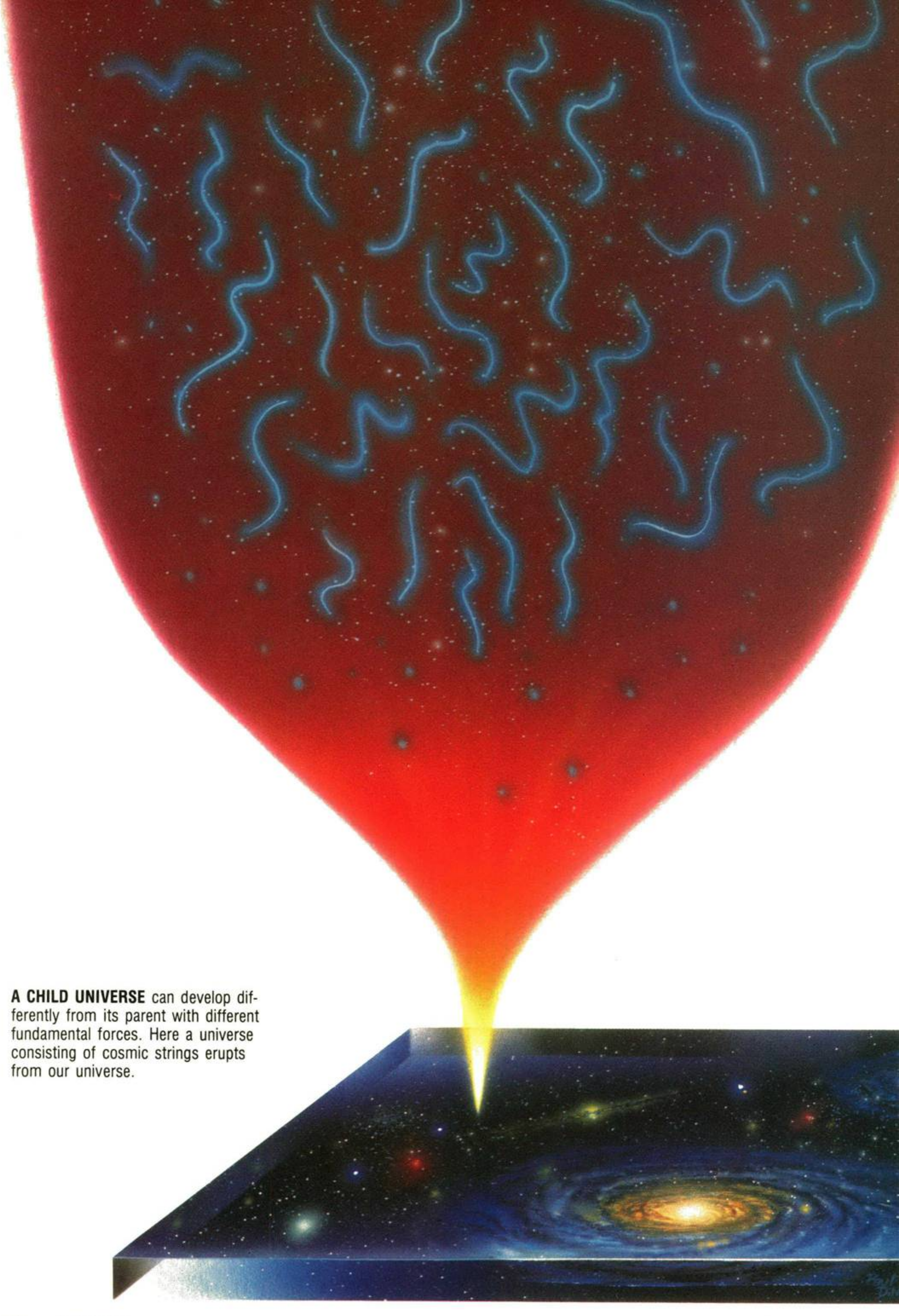
THROUGH THE LOOKING GLASS

If you could step through a black hole you might come out in an entirely different universe that is curiouser than your own.

by George Greenstein



OUR UNIVERSE SPRINGS FORTH from a "seed" of infinite density and temperature and expands in directions that don't exist in the parent universe.



A CHILD UNIVERSE can develop differently from its parent with different fundamental forces. Here a universe consisting of cosmic strings erupts from our universe.

To create a universe in the laboratory, you need about twenty pounds of stuff. What kind of stuff? Any kind: gold will do as well as lead, or potatoes, or bricks. The important thing, and the most difficult to achieve, is that you crush this material to the super-hot and super-dense conditions thought to exist within the inferno of the Big Bang. So let the fires of the laboratory beat down; let the vises groan.

Suddenly a transformation: Amidst the brilliant light of this fireball, the twenty pounds of stuff winks out of view. In its place appears a miniature black hole and within the black hole something even more extraordinary: an expanding universe. In an enormous rush, space in this infant universe expands and fills with still more matter, itself incandescently hot. This expansion cools the vapors, which eventually coalesce into stars, galaxies, and worlds upon worlds. Volcanoes belch and oceans sparkle. Across broad beaches unimaginable beings move in the light of their sun, while overhead yawn vast expanding gulfs of intergalactic space.

As for the original twenty pounds of matter, it served its function as a seed, a seed from which an entirely new universe sprung. If you have another twenty pounds of stuff lying around, you can do it again.

The Universe in a Nutshell

The last few years have witnessed an extraordinary shift in scientists' ideas about the universe as a whole. While it had been thought that ours was the only universe, the idea that our cosmos might be but one among many has recently been gaining ground among astronomers.

This remarkable vision emerged from recent work on the so-called inflationary theory of cosmology. The original concept of the inflationary universe was proposed by MIT physicist Alan Guth in 1981. Guth was mulling over the Big Bang model of the universe as expressed in theories like Einstein's general theory of relativity. According to this theory, the expanding universe originated in the Big Bang, a cataclysmic eruption of space from a region of infinite density and temperature. But the Big Bang premise had been formulated more than half a century ago, and what Guth now realized was that present-day physics had something new to say about the Big Bang, something unforeseen by previous theorists.

Guth was particularly concerned with two inadequacies of the Big Bang model. The first relates to magnetic monopoles, hypothetical elementary particles that have a single positive or negative pole — like tiny magnets with either a north or a south pole. Magnetic monopoles, the Big Bang theory predicts, should have existed in great numbers in the early moments of the universe. But if they were once so plentiful, why haven't they been discovered? The Big Bang theory provides no answer.

The second inadequacy of the Big Bang model relates to the cosmic microwave background radiation, the faint residual glow of the Big Bang that permeates the universe. Observations of this glow reveal that even widely separated regions of space had been equally hot back then. But how could these disparate regions be equally hot if they were never close enough to exchange heat with each other? It is similar to finding that Acapulco and Antarctica have the same temperature.

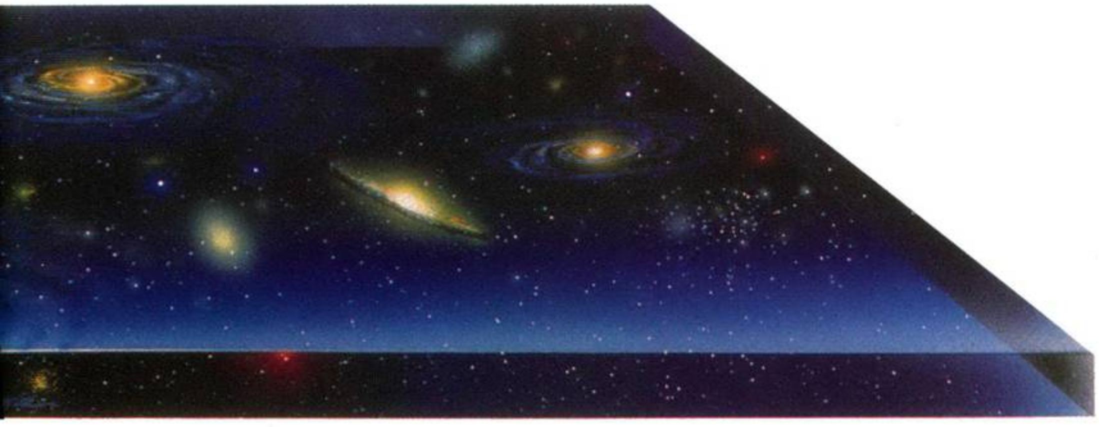
Guth realized that both problems would be solved if the universe had undergone an ultrarapid expansion during the Big Bang. The scale of this expansion goes far beyond those envisioned by previous theorists. He termed this new super expansion "inflation." It is difficult to ponder the magnitude of Guth's inflation. A similar expansion would begin on the scale of a single pea that would puff out to a size greater than that of the entire universe visible through our greatest telescopes. It is even more extraordinary that this flowering, according to Guth, took place in 10^{-34} seconds.

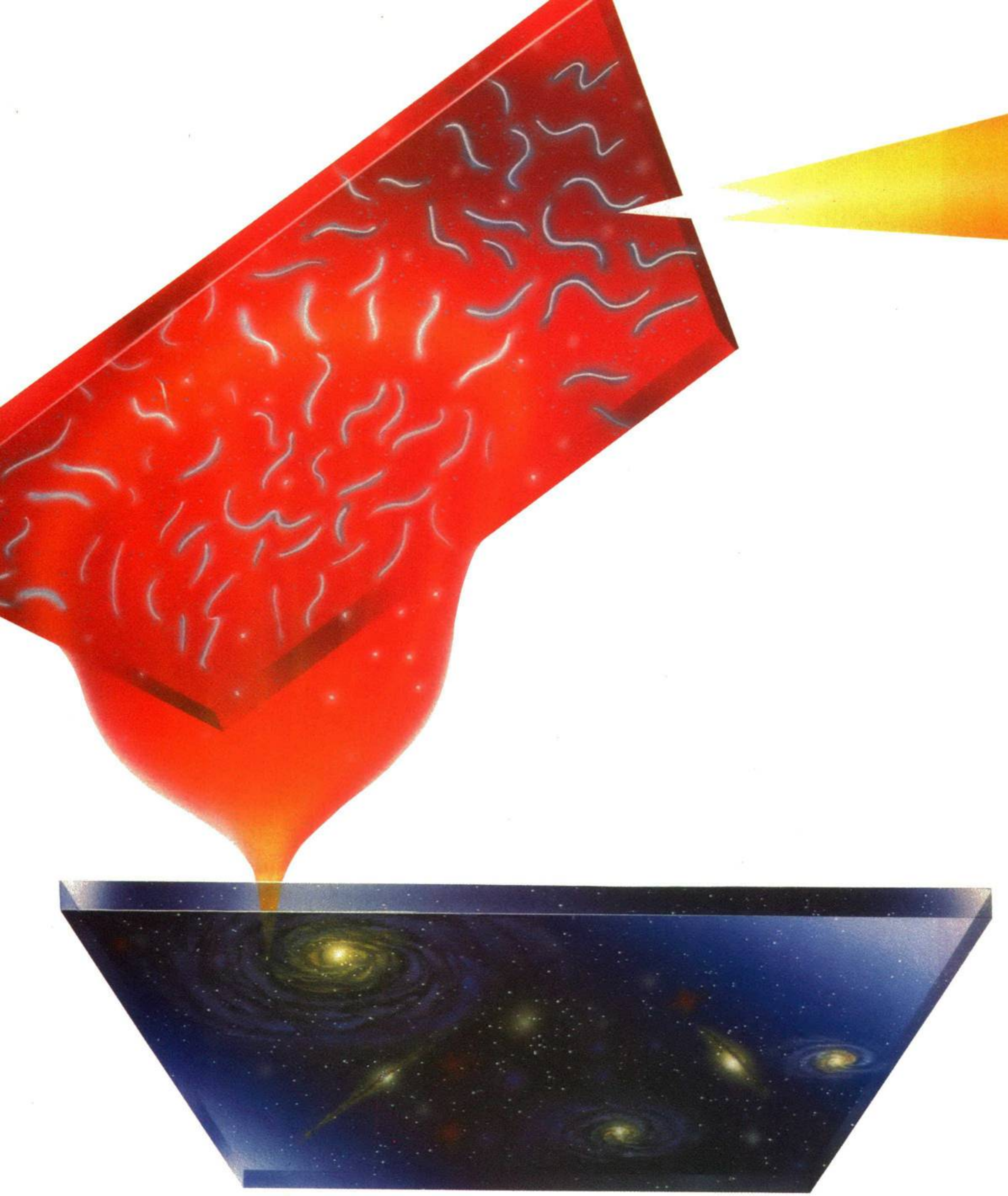
The entire universe we observe today flowered from a region of space initially containing a mere twenty pounds of matter.

Inflation neatly solves the problem of the missing magnetic monopoles by merely sweeping them away to great distances: they exist, but by now they are so far away that they are beyond our detection. Inflation also solves the problem of how widely separated regions of space can have the same temperature. Prior to inflation, no region was widely separated from the other. Then, while in contact, their temperatures equalized.

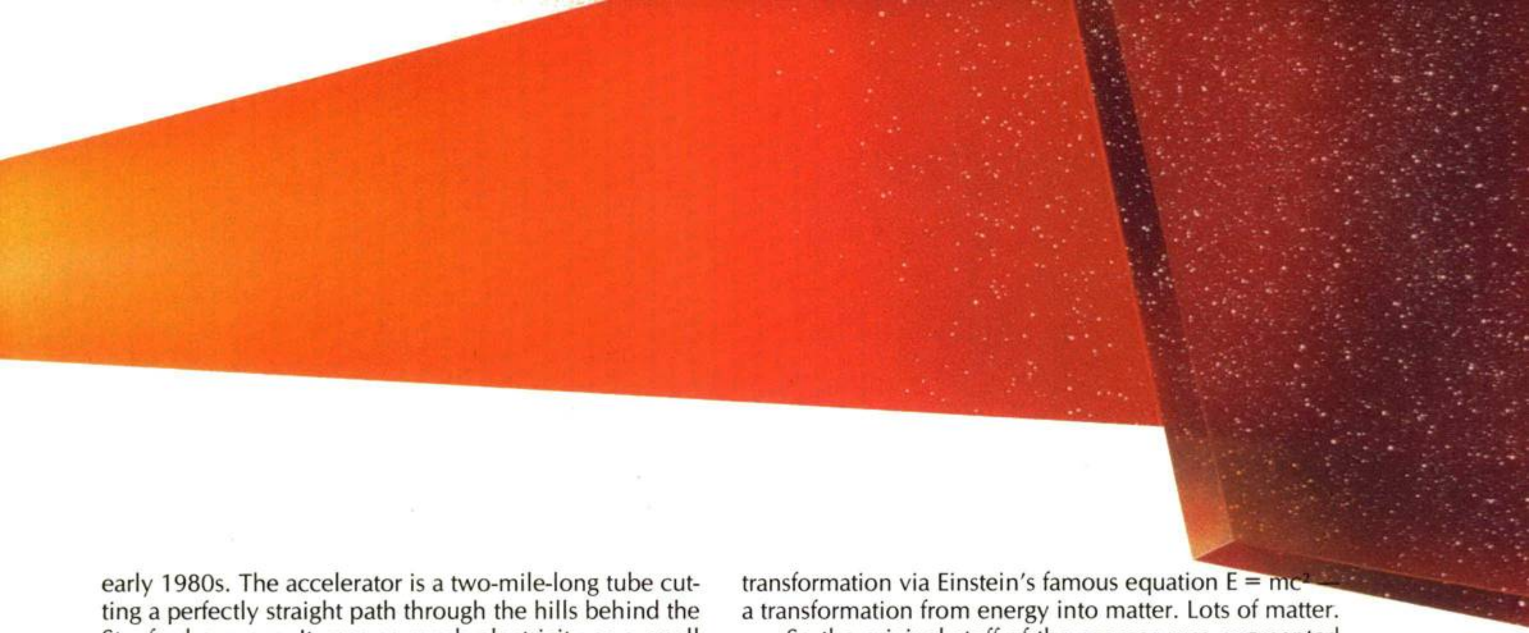
But what caused inflation? This is a key question because the cause and nature of inflation greatly determines the path a child universe takes after "birth."

Guth, an elementary-particle physicist, was at Stanford University's Linear Accelerator Center during the





UNIVERSES PRODUCING UNIVERSES of untold variety form an endless chain of creation.



early 1980s. The accelerator is a two-mile-long tube cutting a perfectly straight path through the hills behind the Stanford campus. It uses as much electricity as a small city to accelerate a stream of electrons to nearly the velocity of light. As the electrons emerge from the accelerator, they are directed towards a target. There, collisions of inconceivable intensity strain matter past the breaking point. By studying the evanescent splinters hurled from these particle collisions, physicists hope to understand the ultimate nature of matter.

In 1974 a theory known as the grand unified theory of particle physics was proposed. In this theory all phenomena pertaining to particle collisions are treated as separate manifestations of the same underlying unity. Guth focused on a prediction this theory makes about the collisions of ultrahigh-energy particles. According to the grand unified theory, in such circumstances an utterly new and unfamiliar form of energy appears: the condensation energy.

Condensation energy is energy released by a fundamental change in the state of matter. For example, changing water from a liquid state to a vaporous state by boiling requires energy, but the reverse transformation — from vapor to liquid — *releases* energy. This transformation is known as a phase transition. When the universe expanded and cooled during the Big Bang, it underwent a phase transition similar to the one that water vapor undergoes when it cools and condenses into liquid. The condensation energy released during the phase transition drove the inflation.

Think of the Big Bang as an immense particle accelerator. If particle collisions in a sufficiently powerful accelerator can trigger the appearance of a modest condensation energy, then the ultraenergetic furnace of our creation would have led to the appearance of a condensation energy the likes of which has never been seen. Early Big Bang theorists certainly knew nothing of it, and their theory of the expansion of the cosmos did not account for it. Guth, however, recognized that the energy produced by the phase transition would have forced the cosmos to expand during the Big Bang more rapidly than Einstein thought possible. It would have forced the cosmos to inflate.

Equally important is the ultimate fate of the condensation energy. It could not have persisted forever. After a brief inflationary epoch, which lasted all of 10^{-32} seconds, the universe settled down into a more sedate expansion. After inflating, however, the gigantic condensation energy did not simply waft away like so much smoke. Rather, it underwent an almost instantaneous transformation via Einstein's famous equation $E = mc^2$ — a transformation from energy into matter. Lots of matter.

So the original stuff of the cosmos was augmented by the appearance of more stuff. The original matter, Guth realized, functioned as a kind of seed, triggering the appearance of the condensation energy, which then transformed into more matter after inflation. Most remarkable of all was the sheer quantity involved. So gigantic was that quantity that the entire universe we observe today — trees and mountains, Earth and Moon, the Sun and stars, and the billions of galaxies that can be seen with our most powerful telescopes — all this grand agglomeration flowered from a region of space initially containing a mere twenty pounds of stuff.

Vantage Point to a New Universe

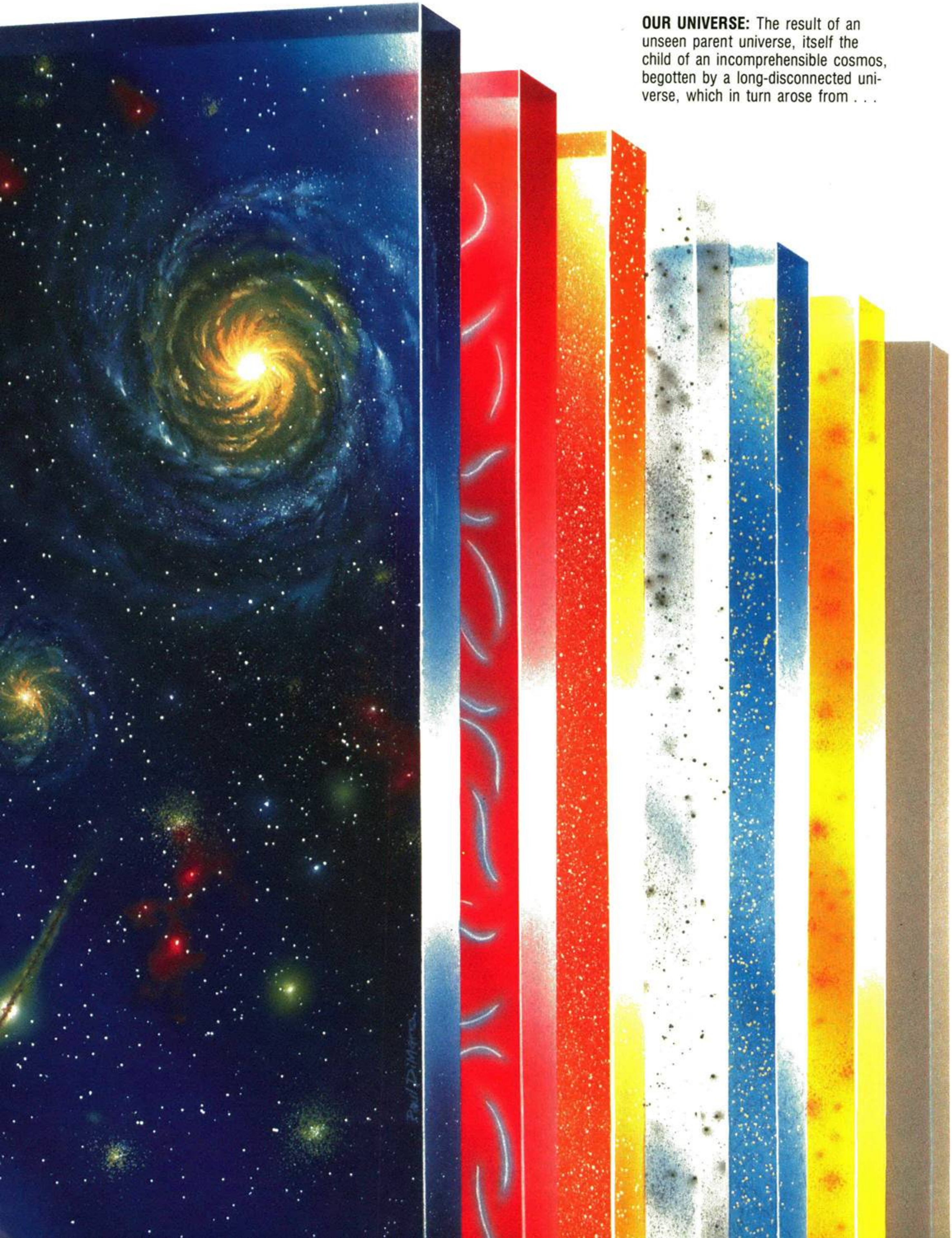
If Guth is right, we are descendants of a seed, and a small one at that. But there are other potential seeds lying around — indeed, because all matter is composed of the same elementary particles, anything at all is capable of doing the trick. The question naturally arises whether it might be possible to produce a universe in a laboratory. What sort of device would we need to assume the godlike role of creator?

In a very real sense, the child universe expands into directions that do not even exist in our universe.

On the one hand, some sort of "vise" is needed, an immense array of battering rams capable of bearing down upon the seed material and crushing it to the enormous temperatures and densities characteristic of conditions during the Big Bang. Perhaps by placing the seed at the very center of an array of hydrogen bombs situated on a tiny moon orbiting Jupiter or Saturn and timing the bombs to explode simultaneously, the seed will catastrophically implode into the required configuration.

And if by an extraordinary effort we succeeded in doing all this, what would happen? Would the seed then evolve into a second universe, complete with its own condensation energy, its own inflation, and the subsequent creation of matter?

It turns out that the actual situation is a good deal more complex. There is a crucial difference between any



OUR UNIVERSE: The result of an unseen parent universe, itself the child of an incomprehensible cosmos, begotten by a long-disconnected universe, which in turn arose from . . .

such simulation and the conditions in the Big Bang. A simulation involves only the seed itself, whereas during the Big Bang this seed is part of a cosmos that undergoes the very same compression and heat.

The consequence of this difference is that what happens in a simulation depends on one's vantage point. Imagine a hypothetical observer located on the surface of the seed, a stowaway ant, for example. As the blast wave bears down, this insect sees the array of exploding bombs suddenly vanish from sight — and not just the array, but the moon on which the array stands, the space surrounding the moon, and, indeed, the solar system and the entire universe. The ant suddenly finds itself immersed in a universe in the throes of its own Big Bang. This universe is undergoing the very sequence of events that Guth believes took place billions of years ago within our own universe. The miraculous bug is a lone witness to creation.

But to external observers, to those of us orbiting at a safe distance from the simulation, the perspective would be quite different. We would see the seed vanish from sight. It would collapse in on itself and form a black hole, an object whose gravitational attraction is so intense that not even light can escape. We would not be able to see the seed flower into a second cosmos or reach within that cosmos to affect events in any way. In a very real sense, it would have expanded into directions that do not even exist in our universe.

And so, hidden from its creators, a child universe is born amid cataclysmic pressures and fires. And what is possible as an experiment is also possible in the universe as a whole. Could natural processes elsewhere in the cosmos be generating child universes at this very moment? Do new universes stream outwards from ours as bits of fluff blown from a dandelion in spring?

And one more question: is our universe the first? Or are we the progeny of some inconceivable parent?

The Anarchic Universe

Everybody knows that conditions in far-off lands differ radically from those nearby. Travel far enough and you encounter strange flora and fauna, climates, and geographies. According to ideas bandied about by astrophysicists recently, this may be true of the universe with a vengeance.

If we could build a spacecraft capable of reaching not just the planets or stars, but far beyond the most distant galaxies that our telescopes can detect, we might encounter places where the very laws of physics are different. Were we to travel off in one direction, we might come upon regions in which the usual elementary particles are absent, their places taken by other particles with natures we can only guess at. Voyaging in another direction, we might find a space that, except for our presence, is utterly devoid of matter. In yet another direction the four fundamental forces of nature might be stronger than in our part of the universe or perhaps weaker, while elsewhere space might possess four, five, or even ten spatial dimensions.

This vision, too, has emerged as a result of recent extensions of Guth's inflation. Until he proposed that concept, astronomers believed physical conditions to be roughly the same throughout the universe, a state cosmologists call *homogeneous*. Actually such a "totalitarian" assumption of uniformity was quite reasonable because telescopic observations reveal that the large-scale universe looks more or less the same in all directions (it is, in other words, *isotropic*). But the inflationary scenario reminds us that this assumption may be incorrect. Our patch of the cosmos, though it appears gigantic, may be but a tiny fragment of the whole; and no matter how great a telescope we construct, it will not be great enough to teach us anything about the whole.

The nice thing about admitting ignorance is that it frees the mind. Some cosmologists have therefore asked themselves what would follow if the normal totalitarian principle were replaced by an anarchic one. They propose that the universe during the Big Bang was actually chaotic in nature and that the condensation energy differed from place to place. Here it was large, there larger, but over there it was zero. Regions of the first sort would undergo normal inflation. Those of the second sort would undergo a far greater degree of inflation and would be quite different from our universe — indeed, it is possible that some regions inflate forever. And finally, regions of the third sort would undergo no inflation at all. By now they may have completed their evolution and collapsed into annihilation in a second Big Bang. Meanwhile, the gigantic inflation of our own region would have carried all these separate "mini-universes" far beyond our ken.

All of this has a crucial bearing on the attempt to unify the forces of nature. Physicists describe all the multitudinous aspects of the world in terms of just four fundamental forces. One is the so-called strong force, which binds the atomic nucleus together, powers the shining of the stars, and is the source of nuclear energy. A second is the so-called weak force, which controls the decay of subatomic particles. Third and far more familiar than the first two is gravity, the universal force of attraction of matter towards other matter. The final force is electromagnetism, which includes electricity, magnetism, and light.

Do new universes stream outwards from ours as bits of fluff blown from a dandelion in spring?

It is hard to see how the electric flow of a current in a wire, the magnetic attraction that twists a compass needle towards the north, and the glimmer of a distant light could all be aspects of electromagnetism. Scottish physicist James Clerk Maxwell proved that this was the case in the latter part of the nineteenth century. Maxwell's achievement still stands out as one of the crowning glories of physics. And in an equally venturesome step, Harvard University physicists Howard Georgi and Sheldon Glashow in 1974 proposed a theory uniting the strong, weak, and electromagnetic forces into one.

The grand unified theory of elementary particles is one of the most important steps forward in physics. Grand unified theories ask why neutrons, protons, and electrons — as opposed to some other subatomic particles — are the ones out of which matter is constructed. It asks why the four fundamental forces exist, and why they have their particular strengths (for example, the electric attraction between electrons). Certain versions even ask why space has three dimensions.

The answers turn out to depend on the history of the cosmos, in particular, on the manner in which inflation ended. But because in a chaotic cosmology the cosmos splits into an endless sequence of mini-universes, each with a different history, the answers are different in different segments. These segments all have different laws of physics. The same may also be true of a universe created in the laboratory. The child grows in ways undreamt of by its parents.

Alternate Universes

The world we live in is an extraordinarily diverse place. Think of the differences between your backyard and the rain forests of Brazil. Compare tropical Brazil with the arid Sahara Desert. Extend your vision further to the permanent night of the ocean floor or the harsh blaze of sunlight on Mercury. Consider downtown Manhattan at rush hour; consider the intergalactic voids.

These radical differences arise from the same underlying laws of physics. (If you accept the cosmological principle, then all places in the universe are alike. There are no privileged locations and physical laws operate the same everywhere.) They are different hands dealt in the same poker game. But differences between ours and the alternative universes envisaged by modern physics must be even greater. These differences are what happen when you change the rules of the game.

To describe the physical principles upon which these new worlds operate is one thing. But to seek to understand what the principles imply is quite another. This is a question that scientists have barely begun to address.

Nature has a way of being more subtle than the subtlest among us can guess.

What would a world be like whose fundamental forces were different? As an example, consider electricity. This force is not merely confined to things such as motors and light bulbs. It is far more ubiquitous and plays a far greater role in the overall nature of things than one would guess from first glance. Through its operation, electrical charges attract and repel one another, and electrically charged particles (the electrons and protons) are the building-blocks of the chemical elements.

Thus the force of electricity has a decisive influence on the elements. It determines what kind of matter exists, and it determines the nature of that matter's chemical reactions. A cosmos in which electricity is more powerful than in ours is one in which the heavier elements of the periodic table simply do not exist — uranium, for example; and iron; and even the carbon, nitrogen, and oxygen so crucial to life. A cosmos with weak electricity, on the other hand, is one containing these elements — but also containing others, far heavier than the heaviest known to us and capable of the most astonishing chemical reactions. Chemistry is at work within our bodies in the never-ending metabolism of the cell. A world with altered chemistry is one in which the nature of enzymes, proteins, DNA, and the mechanism of heredity are called into question.

Properties of the smallest units of the physical world, the elementary particles, have an uncanny habit of percolating upwards to affect large-scale features. Under certain scenarios utilizing the proposed alternative laws of physics, neutrons and protons would not be stable. Rather, their place would be taken by what to us are strange and unfamiliar particles. Neutrons and protons, however, are the constituents of atomic nuclei of which atoms are constructed. So in such a universe *no* atoms could exist. But everything in our physical universe, from stones to clouds to our bodies, is made of atoms. What is a universe composed of if it is not composed of atoms? I could not tell you.

If the more speculative ideas underlying grand unification are correct, the very number of dimensions of space might be different in different universes. The possibility of a fourth dimension has exercised a perpetual fascination and led to the endless conundrums beloved of science-fiction writers. Few of these writers, however, have dared to venture further afield into the possibility of a fifth dimension — or more. And in any event, they have been asking the wrong question. The question they should ask is not what it would be like for three-dimensional creatures to visit such a world, but what it would be like to *be* a higher-dimensional creature.

A Universe is a Universe is a Universe . . .

In practical terms, the artificial creation of a universe is not feasible because the required physical conditions lie far beyond anything that we are capable of achieving today. No furnace and battering ram, no array of hydrogen bombs that we could assemble would be remotely capable of mimicking the Big Bang.

A recent study has indicated that the required conditions might turn out to be even more extreme. In fact, they might turn out to be infinite — a literally infinite degree of compression and temperature. If true, this would not be just a formidable obstacle but an absolute one. It would lay to rest the possibility of creating a universe for all time. But whether it is true is right now an open question.

Although spectacularly successful in theoretical terms, the grand unification theory has essentially no experimental successes to its credit. Our accelerators are not powerful enough — and may never be — to reach the energies required to test the theory. It is always dangerous to put too much faith in such things: nature has a way of being more subtle than the subtlest among us can guess. Similar caveats surround the notion of a universe composed of an endless succession of mini-universes.

All these ideas lie at the very cutting edge of research. They are not proven concepts. They are dreams, hopes, and speculations, and it would be foolish to claim that they will retain their present form as science progresses. Nevertheless, we stand at a great juncture in the evolution of our ideas about the cosmos. Modern theories of elementary particle physics have given us an extraordinary vision: a glimpse of a universe of universes, of a never-ending sequence of parallel worlds. And more than that, they have posed a major challenge to our powers of imagination. □

George Greenstein is a professor of astronomy at Amherst College in Massachusetts. He is the author of Frozen Star *and* The Symbiotic Universe.

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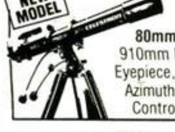

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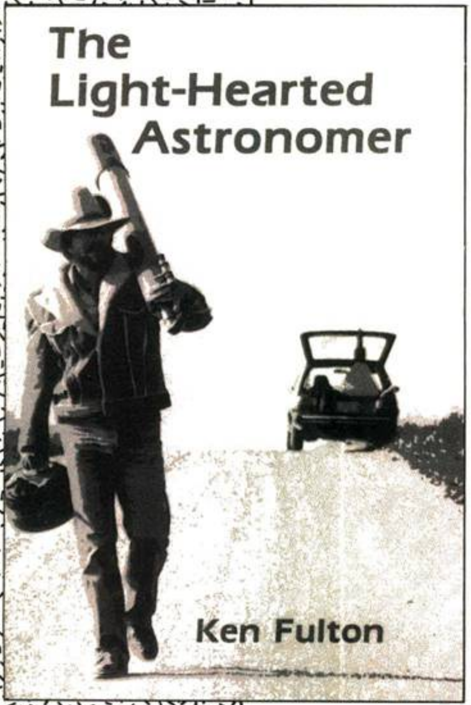

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First Discoveries at NEPTUNE

A "Great Dark Spot," bands of clouds, and a new satellite were revealed by *Voyager 2* as it approached Neptune.

by Richard Berry

As *Voyager 2* raced toward Neptune in June and July, its cameras revealed more and more detail to waiting scientists. As newer and sharper images showed cloud structure invisible only weeks earlier, the scientists watched, pondered, and speculated on the unfamiliar planet before them. An entirely new world was being unveiled.

On July 7 *Voyager* project scientists announced that they had detected a new satellite — temporarily dubbed 1989 N1 — orbiting Neptune. The discoverer of the satellite, Stephen Synnott of the Jet Propulsion Laboratory, used the satellite's brightness to estimate that it is 200 to 600 kilometers in diameter.

At the time of its discovery in mid-June, 1989 N1 was too distant to show up as anything more than a faint smudge of light. As *Voyager* approached Neptune, scientists expected pictures of the satellite to reveal a crater-pocked surface.

When the discovery was announced, the newly found satellite had been observed on seventeen *Voyager* narrow-angle camera frames taken over a three-week interval. Analysis of the frames shows that 1989 N1 orbits Neptune in a nearly circular, prograde orbit; is circling in the equatorial plane of the planet; and has a period of 1 day 2 hours and 56 minutes.

Meanwhile, *Voyager* radioed hundreds of images of Neptune back to Earth. The most obvious feature on the Neptunian globe is a large dark oval feature at 25 degrees south latitude. Unofficially dubbed "The Great Dark Spot," the feature is some 6,000 kilometers long and 2,500 kilometers wide and has been visible to the *Voyager* cameras since last February.

Spots like the Great Dark Spot are ubiquitous on the gas giant planets. Jupiter has three large white ovals at the same latitude as the Great Red Spot and dozens more at other latitudes. At any given time Saturn has several dozen transient spots, and even nearly featureless Uranus gave evidence of short-lived spotlike features. "In general there are more spots away from the equator," said California Institute of Technology planetary physicist Andrew Ingersoll. "The little spots haven't gotten enough attention."

But is Neptune's Great Dark Spot really a Great Red Spot?

"Obviously, it looks like the Great Red Spot," said Ingersoll, "but we don't have much dynamical information about it — we don't know how it moves. We haven't measured the flow field. At this point we don't even know if it's a cyclone or an anticyclone."

In order for planetary scientists to put Neptune's Dark Spot in the same class as Jupiter's Great Red Spot, Ingersoll explained, the Dark Spot would have to satisfy tough criteria. "It has to be an anticyclone, that is, have high pressure in the center." Second, the Dark Spot would have to be embedded in a shear zone. "The Great Red Spot rolls like a balloon caught between two conveyor belts going in opposite directions," Ingersoll said.

Third, it would have to draw energy from the surrounding atmosphere. "The Great Red Spot eats up other spots, little ones, and in doing so gains energy from them," said Ingersoll. Finally, the Great Red Spot and two of Jupiter's white ovals sit on a pressure ridge in the atmosphere. The existence of the pressure ridge implies that there's an invisible flow underneath the Great Red Spot and means that the deep atmosphere of Jupiter does not rotate like a solid body.

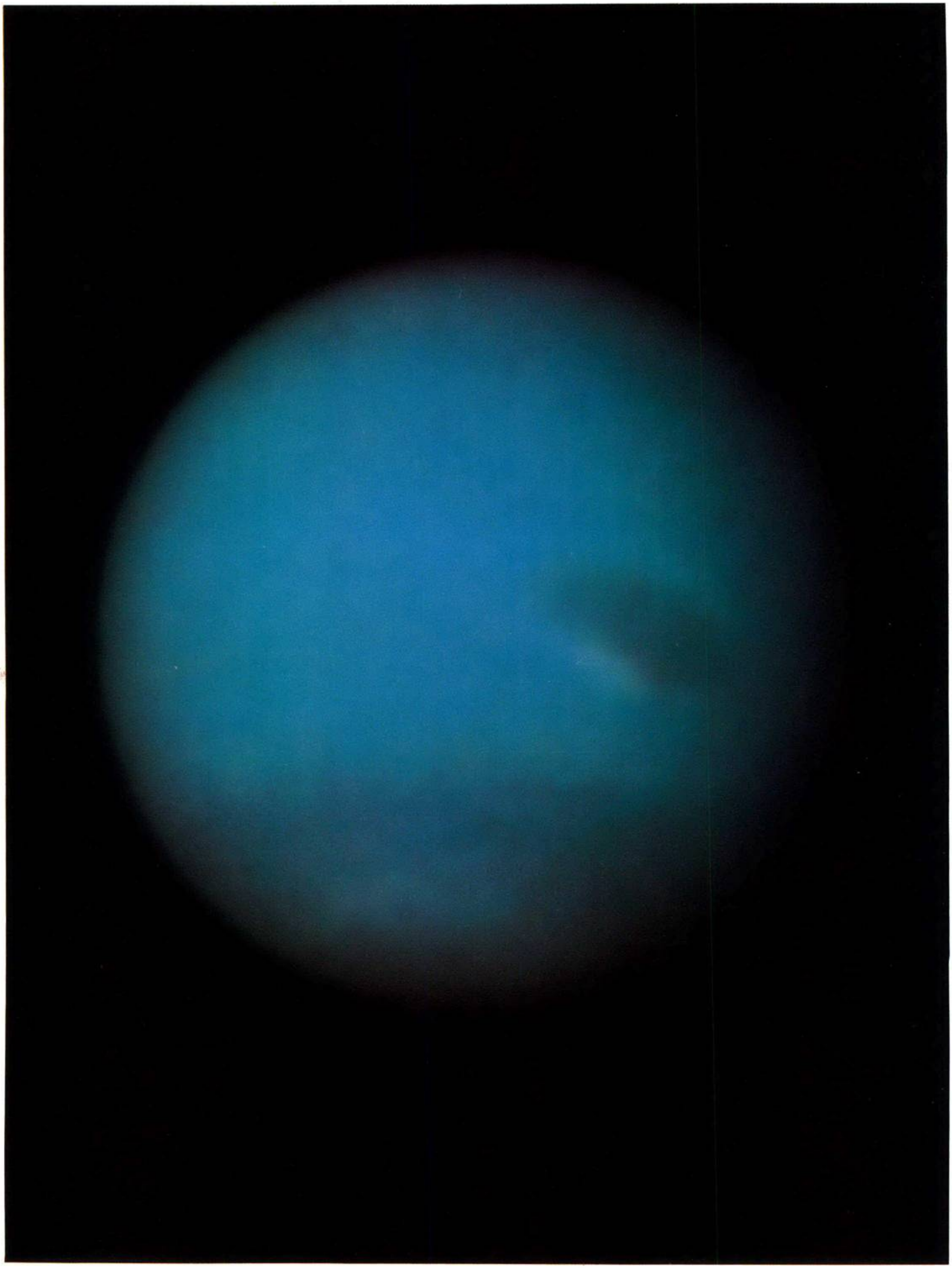
Also withholding judgement about the Great Dark Spot is planetary astronomer Heidi Hammel of the Jet Propulsion Laboratory. "Its color and brightness aren't like the Great Red Spot," Hammel said. "It's tempting to equate them because the Great Dark Spot is a big system, and it's persistent. But it's in a really different pressure and temperature regime. Neptune is much colder than Jupiter." As *Voyager* closes on Neptune, its cameras will reveal whether the Great Dark Spot resembles the Great Red Spot in more than just looks.

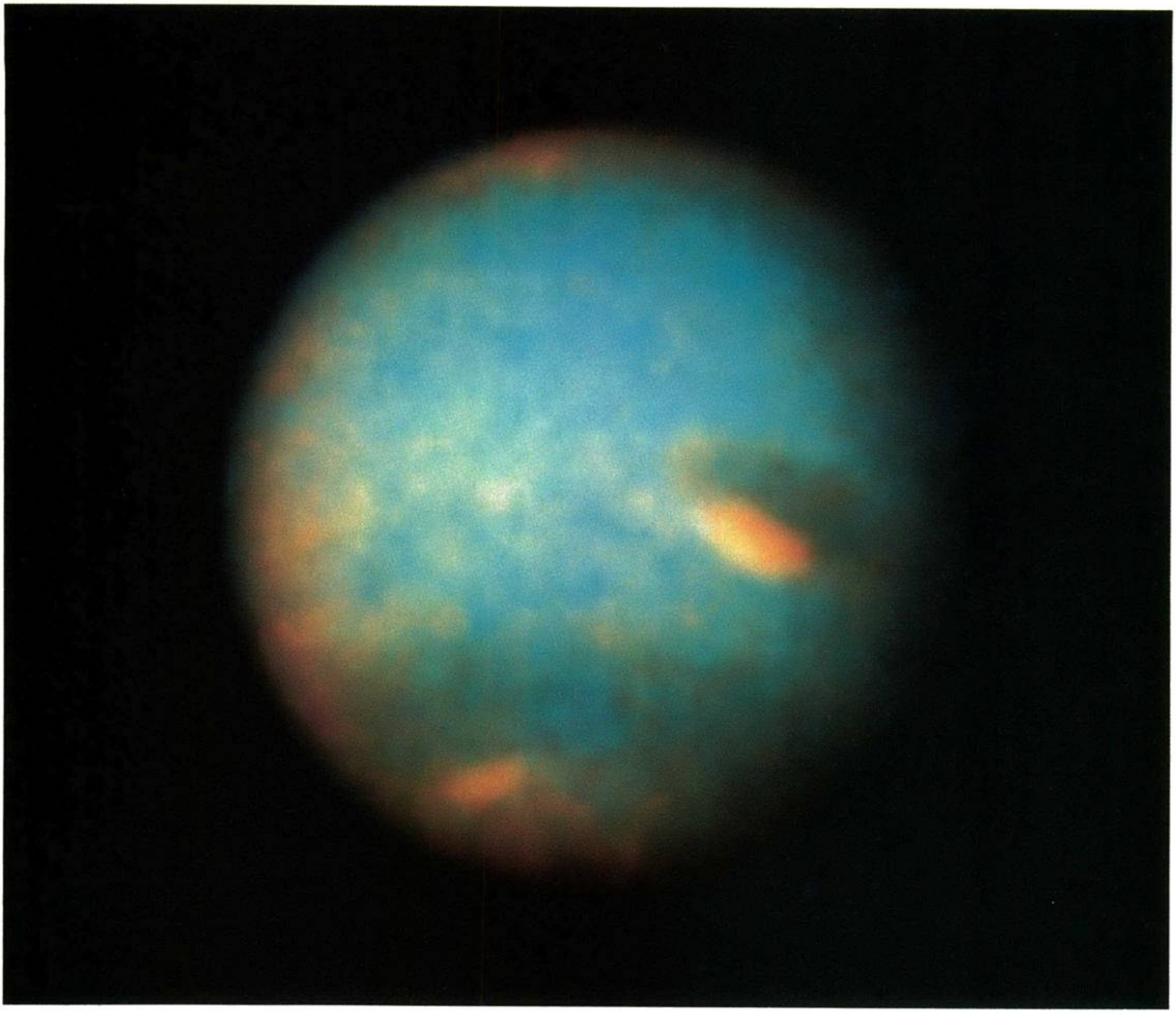
Along the southern edge of the Dark Spot, *Voyager*'s images show a prominent white or orangish companion feature some 4,000 kilometers long and 1,600 kilometers wide. *Voyager* astronomers have been watching to see whether the Dark Spot and its white companion would remain together or move apart. According to Hammel, the companion has not moved relative to the Dark Spot, so the two may be physically associated.

Other white features near the south pole of Neptune appear to have come and gone in less than one planetary rotation, that is, less than eighteen hours. How these features form and dissipate so rapidly is a mystery. "Dynamical features — things that show vast changes in a day or two — are common in Earth's atmosphere," said Ingersoll. "But the intuitive expectation is that things slow down in the outer solar system." This is because it takes energy to drive dynamic features, and Neptune's atmosphere receives a thousand times less energy per unit area than Earth's atmosphere does.

The problem that atmospheric dynamicists face is explaining where Neptune gets the energy for the white features. "There are really three pos-

BLUE-GREEN NEPTUNE would appear like this to human eyes. Methane in its atmosphere absorbs red and orange light, so Neptune reflects only blue, green, and yellow light.





A COLOR-ENHANCED VIEW exaggerates Neptune's colors and contrasts. The Great Dark Spot and its orangish companion are the most prominent features.

Neptune's Known Satellites

(as of July 20, 1989)

Name	Distance	Orbit
1989 N1	117,500	Circular, prograde equatorial
Triton	354,290	Circular, retrograde, inclined 21 degrees
Nereid	5,511,000	Highly eccentric, prograde

Distance given in kilometers from Neptune's center.

sibilities," said Ingersoll. "First, we've been fooled by the pictures we've looked at and the changes are not rapid. Second, the white spots really do show rapid changes, but there's not much energy dissipated in them. The third is we're seeing big changes in visibility that don't require much energy to drive."

"In my opinion," said Ingersoll, "the biggest news so far is that there's something there to see in Neptune's atmosphere." Neptune, in fact, shows cloud bands parallel to the direction of rotation just as the other outer planets do. Even nearly featureless Uranus shows faint cloud bands despite facing almost pole-on to the Sun. "Cloud belts are apparently a general property of rotating planets," said Ingersoll. "We even see them on Uranus where the day-and-night pattern of sunlight is all messed up."

As *Voyager* moves closer to the huge green globe of Neptune, what we know about this outermost planet, its satellites, ring arcs, and the array of charged particles trapped in its magnetic field will grow by leaps and bounds.

"*Voyager* was launched at a very fertile time in the American space program," said Richard Terrile, a leading member of the *Voyager* camera imaging team, "and we're still benefiting from it. *Voyager* has shown us that the most exciting things we find when we explore new planets are always total surprises. We have learned from *Voyager* that there is much more variety in the solar system than we ever expected." ☐

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Orion SkyGlow Enhanced filters are the finest broadband light pollution filters you can buy at any price. They feature improved blocking of mercury vapor light, and higher transmission at the critical Hydrogen Alpha and Hydrogen Beta lines than similar competing models, including expensive 'premium' models.

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This effect is particularly apparent when observing or photographing nebulas. Orion SkyGlow Enhanced Filters allow maximum transmission of Hydrogen Alpha, Hydrogen Beta, and Doubly Ionized Oxygen; the light bands most commonly emitted by nebulas. Galaxies and star clusters are also enhanced, but these objects don't show as dramatic an improvement.

An unexpected advantage of the SkyGlow filter is its improvement of planetary images–particularly on Jupiter–especially in conjunction with a colored filter. Without any filters, this bright planet's cloud bands frequently will be only faint, un-detailed smears across the disc. Pop in the filters, and knottings and festoons will appear, and the edges of Jupiter will stand out crisply.

Ideal for both visual observation and color or black and white photography. Why suffer under light polluted skies any longer? Order your Orion SkyGlow Enhanced Light Pollution Filter today under our 30 day money-back guarantee.

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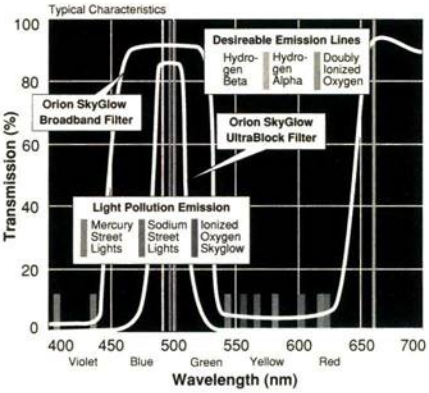

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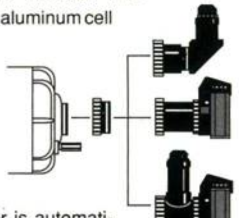
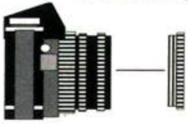
The Broadband models are the best choice for use in areas of moderate light pollution, and for astrophotography from all areas. The UltraBlock models are best for visual use in areas of substantial light pollution. For more specific transmission data, ask for our SkyGlow™ tech sheet. You may wish to purchase both types of filters if you observe from several locations.

Three Different Mechanical Designs

•The **1.25" models** are mounted in a precision threaded cell which fits all standard 1.25" eyepieces. Additionally, it will fit some star diagonals and many universal 1.25" camera adapters such as our #5264. It is ideal for general visual observing, and for photographic use if compatible with your camera adapter.



•The **Schmidt-Cassegrain models** fit all Celestron and Meade 4", 8", & 10" models. The double-threaded heavy aluminum cell fits directly to the back of the telescope, allowing attachment of *any* photographic or visual accessory. You can attach your usual visual back and star diagonal, so that the filter is automatically in place as you switch eyepieces. You can also attach your camera T-adapter or Off-Axis Guider for photography using your SkyGlow filter.



•The **52mm Camera Lens model**, (available with Broadband optics only) is designed specifically for piggyback camera astrophotography with single-lens reflex cameras. It threads directly onto 52mm camera lenses, and fits most other lenses using one of the adapter rings listed on facing page.

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A User's Report: "The Orion UltraBlock filter was a real surprise for this observer. The UltraBlock can make deep-sky observing a possibility for the urban dweller! With a sharp passband centered around desirable blue-green emission lines, it of course reduces the brightness of star images and faint stars, and diminishes the image of globular clusters, but the resultant black sky background is astonishing. On my first try of the UltraBlock, I observed the Orion nebula rising just above my roof early one evening. The entire sky was pink to the naked eye, and hardly any background stars were visible in the telescope; Orion was a washed-out and vague caricature of the stunning sight that it is in a desert sky.

"In went the UltraBlock, and suddenly the faint tendrils of glowing clouds were visible, against a velvety deep black background! I eagerly turned the telescope to the Pleiades, and the UltraBlock unmistakably brought out the nebulosity around several of the brightest stars — in a 4" telescope! In a few moments I had found the vague cloud of M1, which I have never been able to view from my south San Jose front yard. The Andromeda galaxy, which theoretically should not be significantly improved by the UltraBlock, was visible as much more than just the dim round comet-like glow it appeared to be without the filter; I could clearly discern the oval shape of M31, and was able to spot its companion galaxies, which were pitiably vague against the wideband sky light.

"An unexpected benefit of the UltraBlock was the improvement in star image sharpness in the fast f/4 Astroscan, which has considerable coma at the edges of the field. Just about any scope faster than f/4.5 will have this slight distortion. Pop in the UltraBlock, and one finds that bright stars are much cleaner and sharper; not only does the nebulosity in the Pleiades appear against the dark background, but also the center stars approach refractor clarity because only blue-green wavelengths enter the eyepiece.

"Before using the UltraBlock, I had felt that my front yard was suitable only for planetary observing; now that I'm hooked on the UltraBlock, I spot a new Messier object within minutes each time I trot out my telescope."

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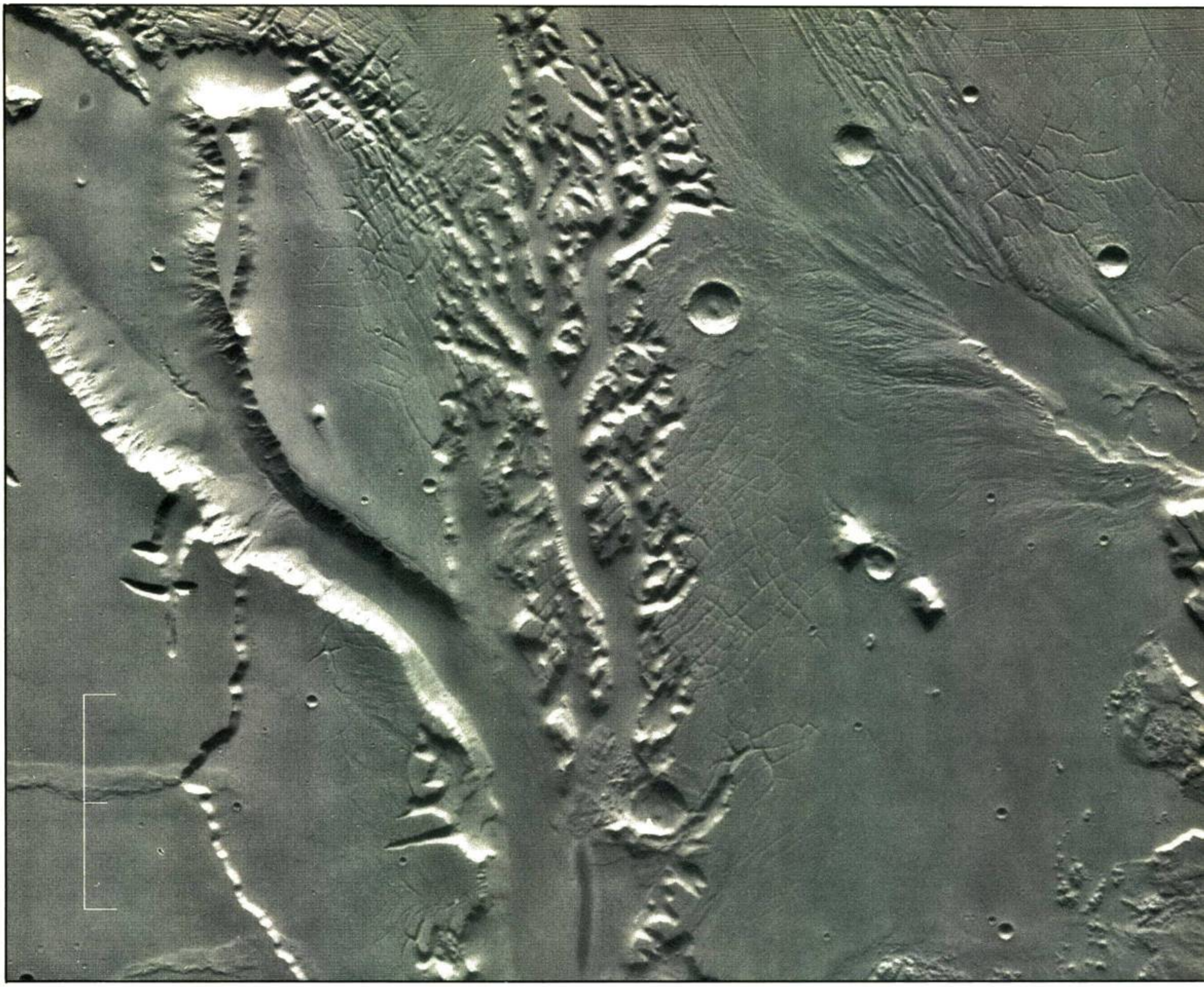


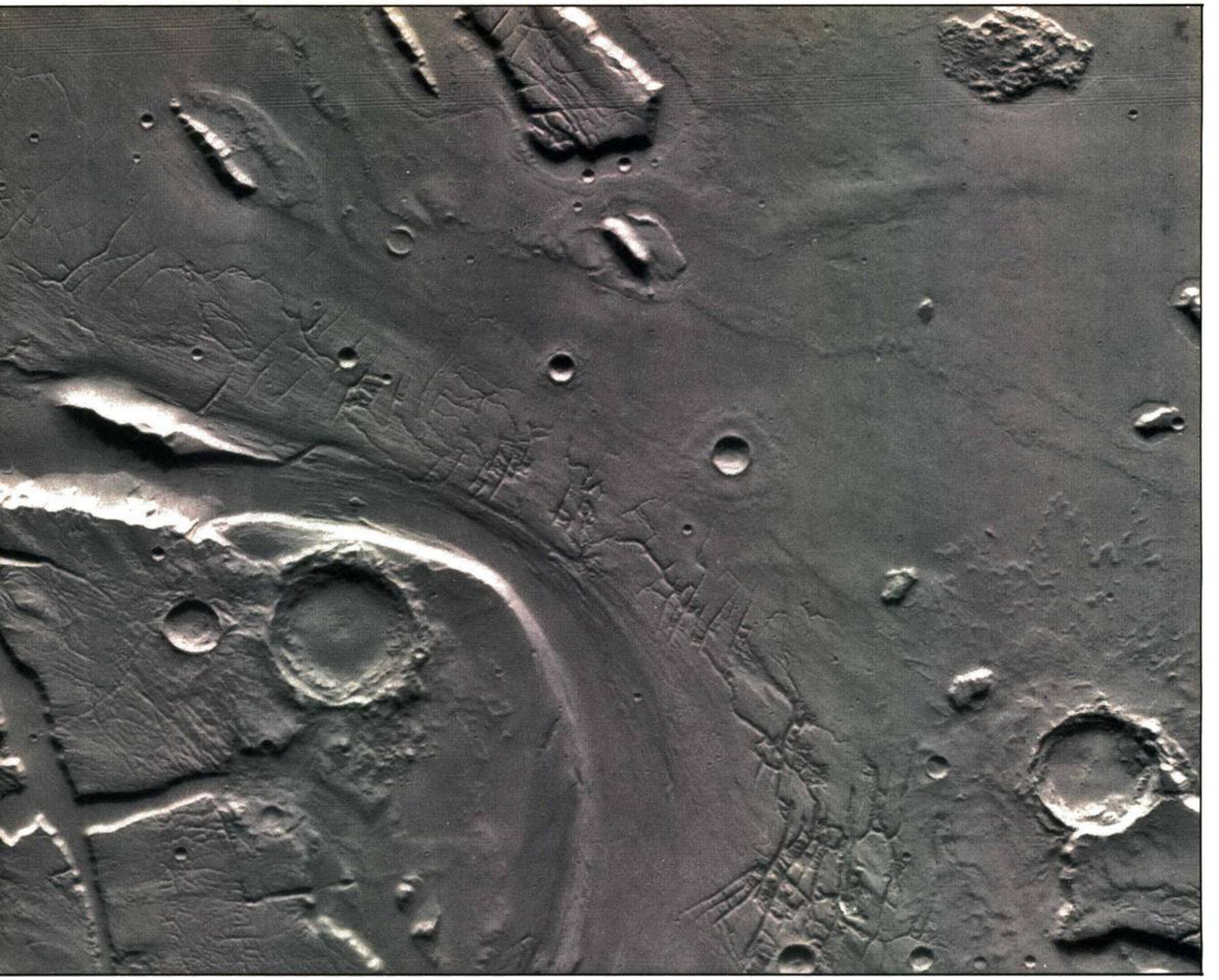
North of Valles Marineris — the "Grand Canyon" near the Martian equator — runs a valley 1,500 miles long and 200 miles across. It is called Kasei Valles, derived from the Japanese word for Mars. The valley's central portion (pictured above) contains examples of every kind of valley Mars possesses. Because it is a veritable "museum" of water-carved landforms, planetary scientists such as myself are studying Kasei closely to learn more about the processes that have shaped the surface of Mars.

The scenes you'll see on the following pages don't look markedly different from scenes throughout the American Southwest. Mesas and arroyos tell of a desert climate, and the streamlined bars and striations in the channel beds point unmistakably to occasional heavy erosion by water. This isn't Utah, however, it's Mars — and these channels can tell us a lot about the Red Planet's past if we know how to interpret them. (See "Searching for the Waters of Mars" by Steven Squyres, August 1989.)

While working with Ken Tanaka of the U.S. Geological Survey, I became interested in Kasei (pronounced ka-SIGH) because this region provided perfect opportunities to study the floods that have deluged many parts of Mars and deeply eroded its landscape. Was Kasei formed by one flood event or several? When did the floods occur? How big were they? We don't yet have more than rough answers to any of these questions. Certain features point to repeated flooding, and the valley may be a billion years old, or twice that, or even older still. However, we *do* know that the floods that created Kasei were immense, larger by far than anything on Earth.

Gauging floods that dried up ages ago isn't easy. The starting point is to determine the size, volume, and slope of the channel left behind by the floods. This presents a problem, however. While *Viking* photos from Martian orbit provide clear enough views, they lack essential information on elevations. Elevations are critical because without heights and depths, a Mars photo, no matter how informative, is just a two-dimensional brocade of light and dark areas. Unfortunately, the *Viking* orbiters carried no altimeters, so there is no global network of elevations relative to Martian "sea level."

Completely fortuitously, however, *Viking* did take overlapping stereographic pairs of images of certain

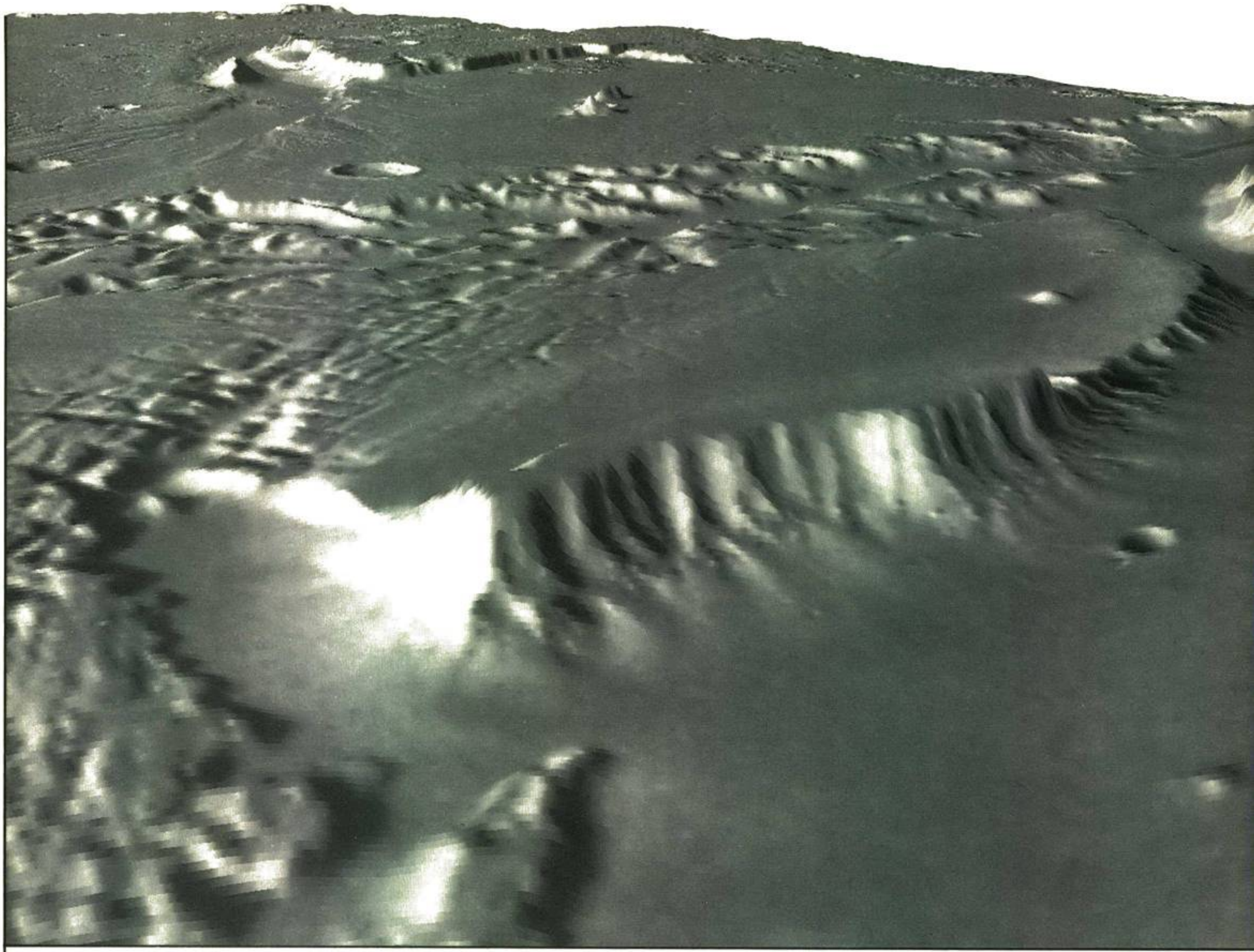


PLANETARY SCIENCE

Surveying the Scars of Ancient Martian Floods

With computer-generated images of Mars' Kasei Valley, planetary scientists can take an aerial tour of a slice of the planet's geologic past.

by Mark S. Robinson

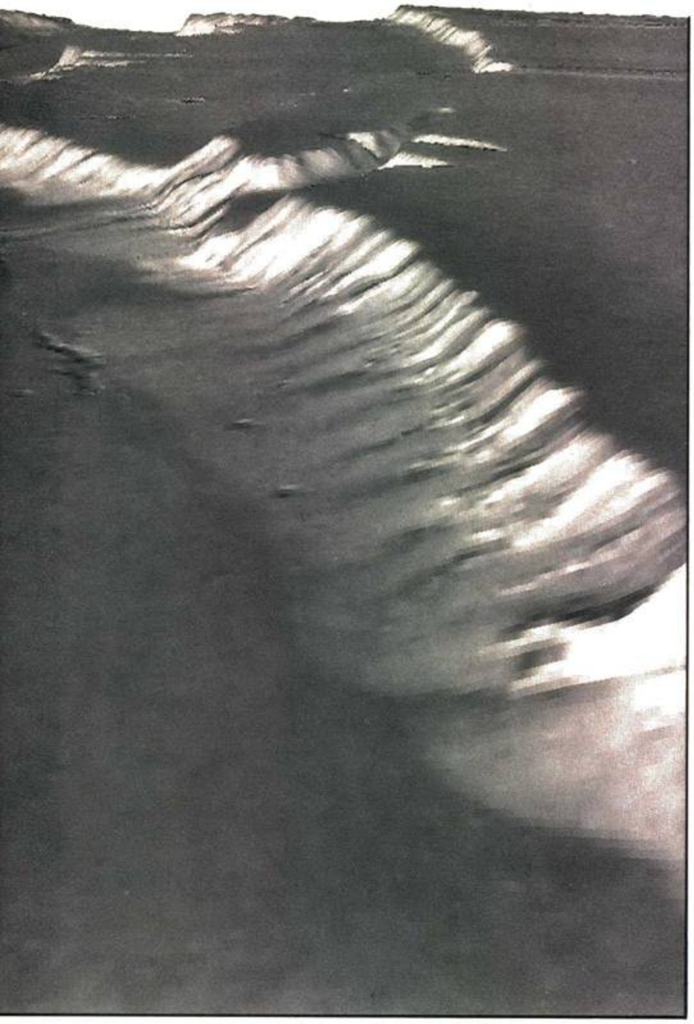


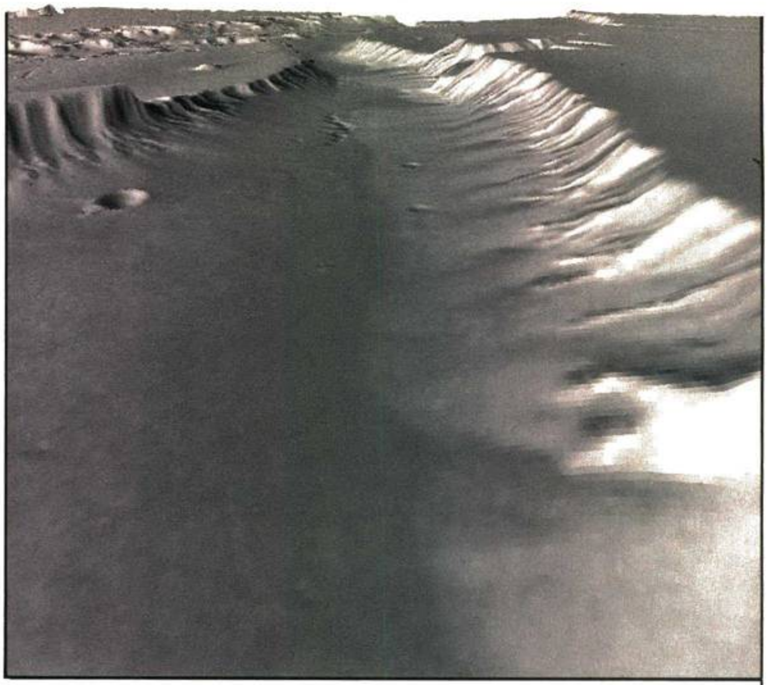
FROM FIVE MILES HIGH the flood-carved southern branch of Kasei Valles stretches downstream toward the right. The mesa (left foreground) stands about 10,000 feet higher than the valley floor. Beyond the mesa lies a network of valleys called Sacra Fossae.

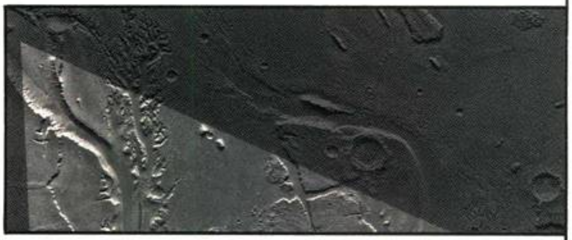
areas, including Kasei. These image pairs, analyzed by the U.S. Geological Survey, allow planetary scientists to draw contour lines and to measure the highs and lows of the land. The stereogrammetry revealed broad regional slopes as well as simple things like crater depths.

These elevations were compared with elevations derived from a computer analysis of shadows, also developed by the USGS. (Geometry can tell you the height of an object from the length of its shadow when the Sun's position is known.) This analysis produced slope angles, which are based on how pixels change brightness along a profile line. In the end the two processes yielded an accurate map of heights and depressions for the Kasei region on top of which the computer draped a smoothly blended mosaic of *Viking* photos. The result was a three-dimensional image of Kasei Valles stored in a computer.

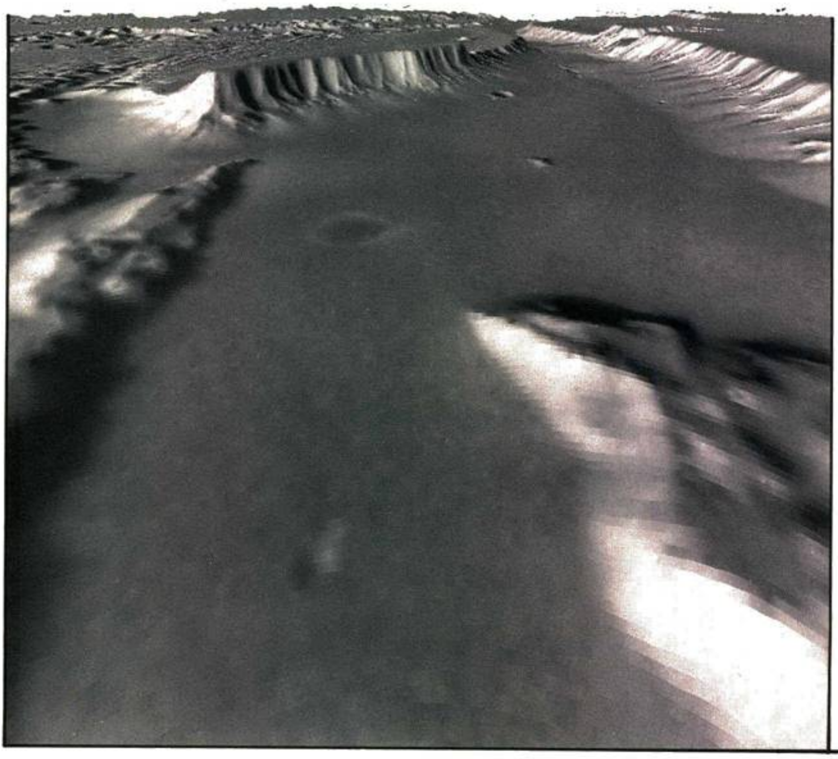
This "digital Kasei" serves two related purposes. First, by determining the slopes of the channels and peak flood levels, I could calculate the volume of water that once flowed in the channels, which came to about a cubic kilometer per second. This figure is extremely large, even when allowing for the inevitable errors of measurement. To put it another way, the peak volume of flow was ten to hundred times the size of the flood



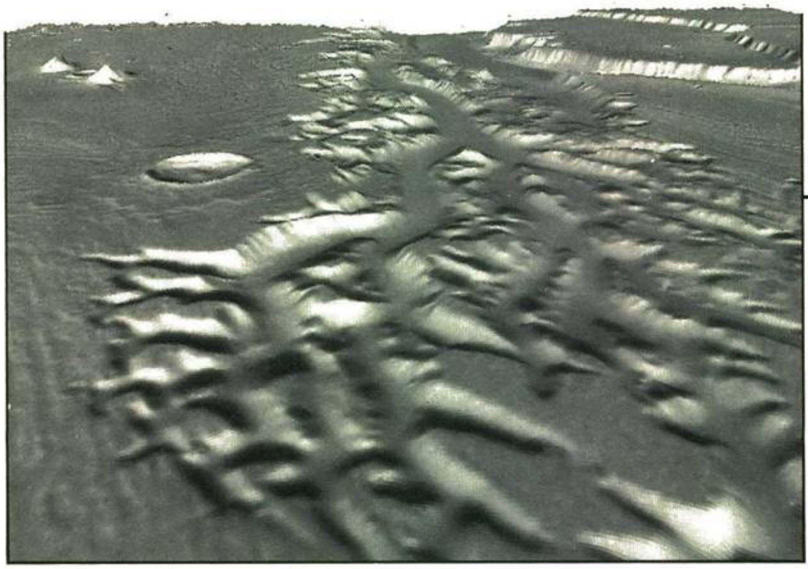




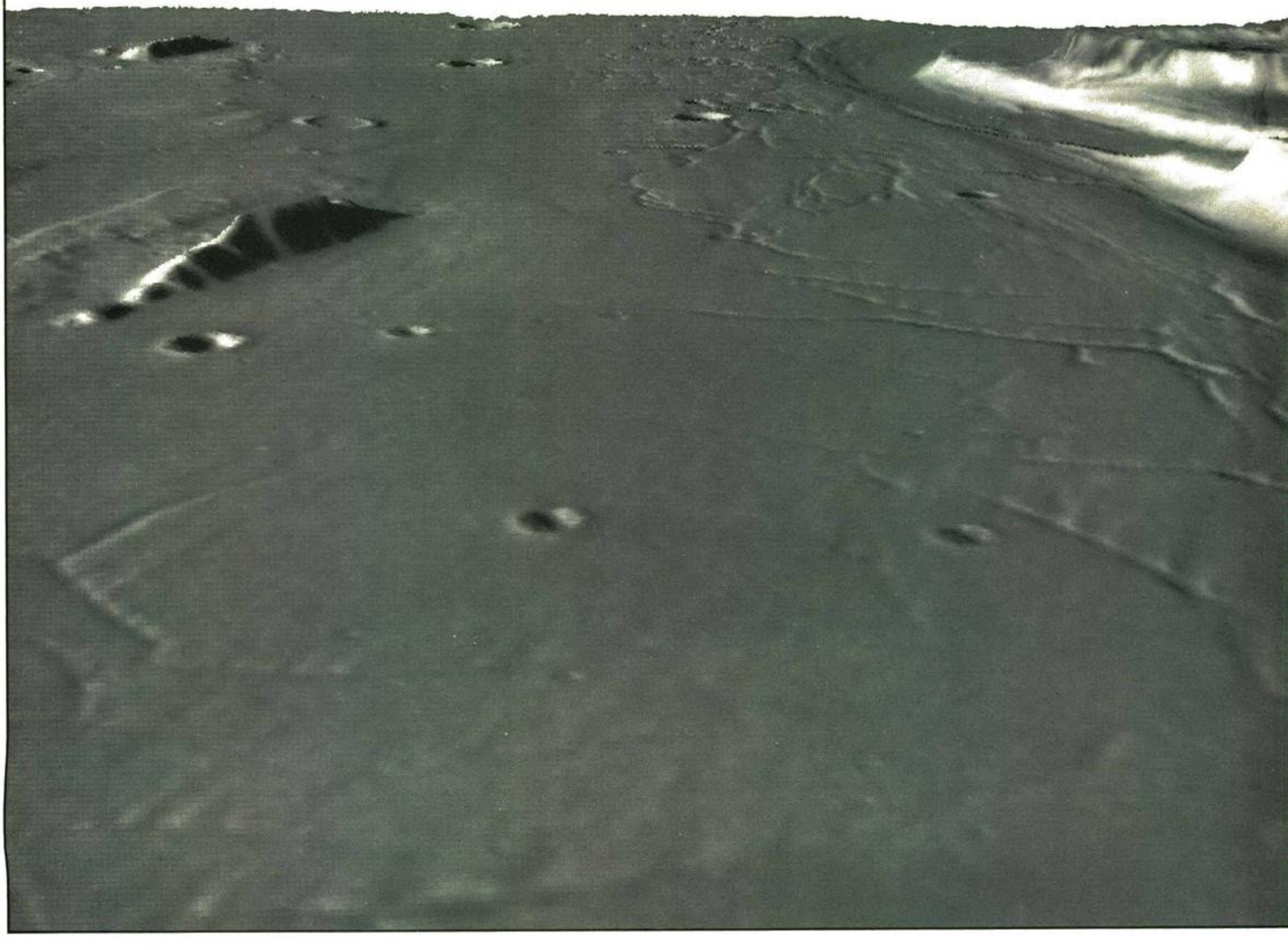
ZOOMING DOWN the south channel shows valley walls scarred by landslides. In the far distance faulting or erosion has dropped a large section of the valley wall about 3,000 feet to form a broad shelf.



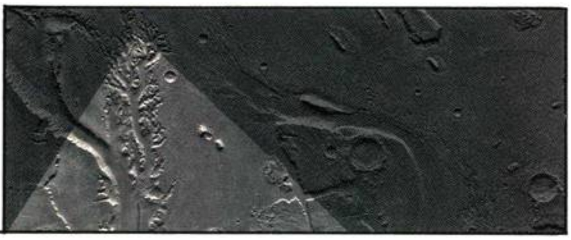
A REMARKABLY SMOOTH FLOOR lines the southern channel. The oval spot (upper center) appears to have no topographic relief, yet it is not a photo defect. Its nature is unknown.



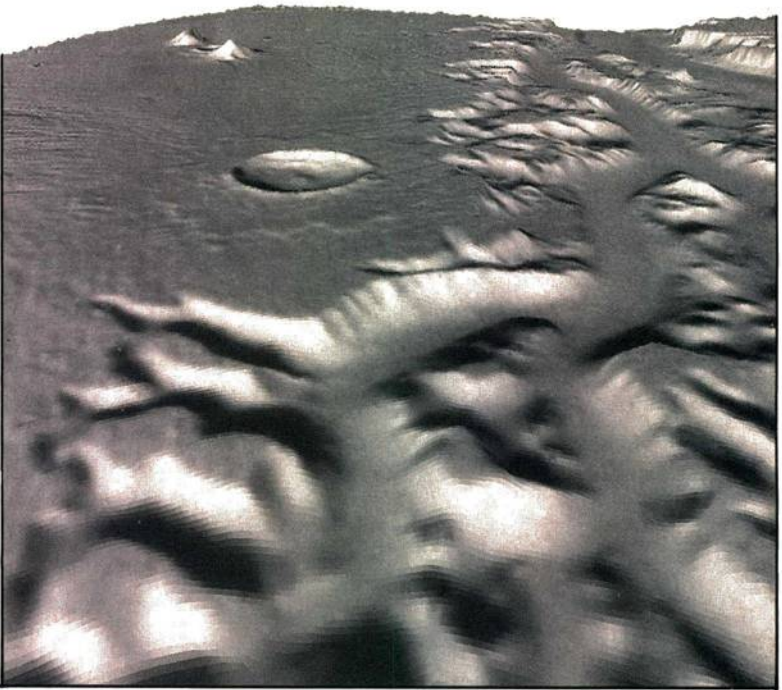
KASEI'S NORTHERN CHANNEL skirts a mesa about 8,200 feet high (center). Here flood waters surged from the right side, leaving linear scour marks. They also half-eroded and buried the crater in the channel before dividing around the hogback ridge (center).

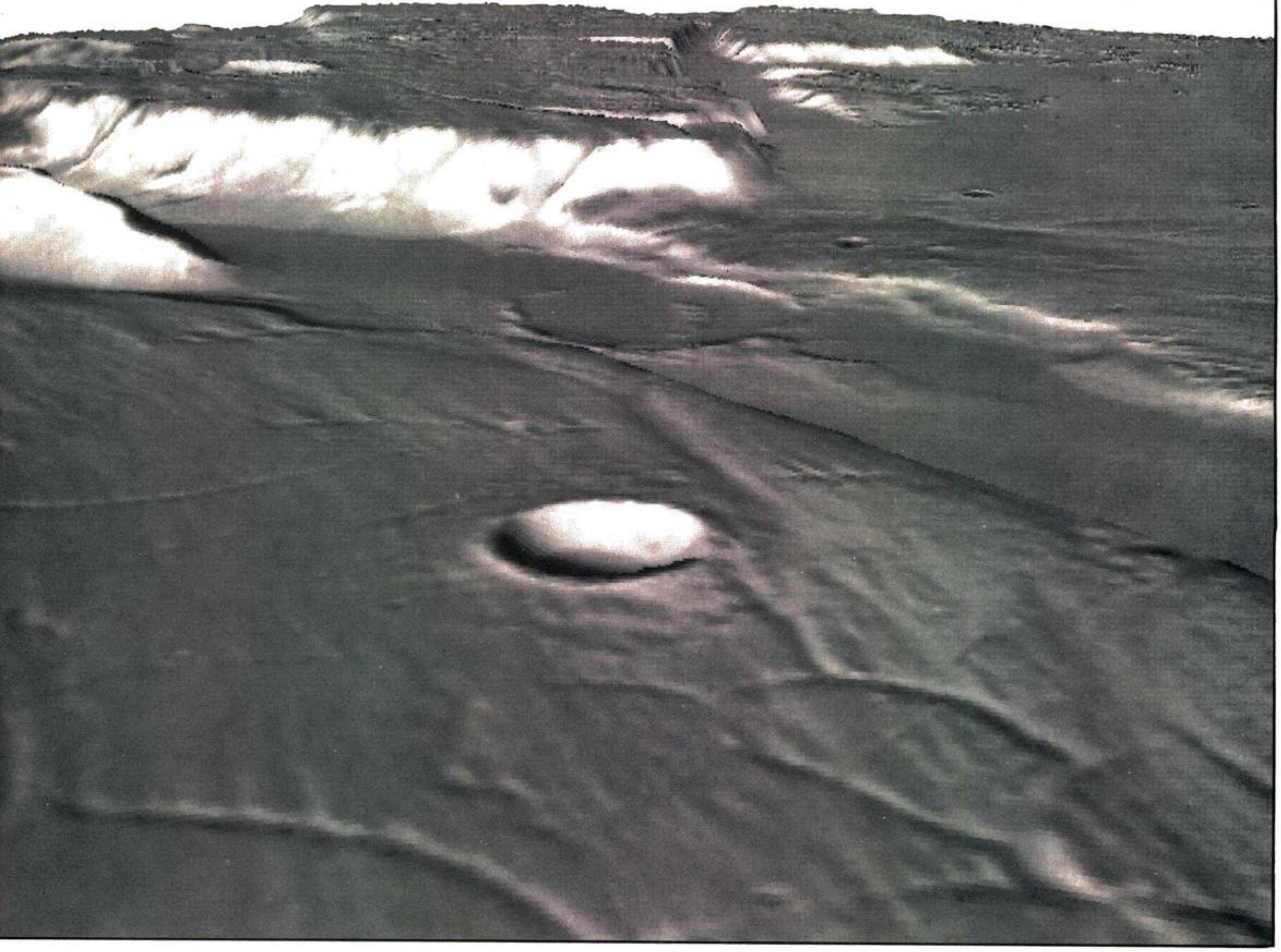


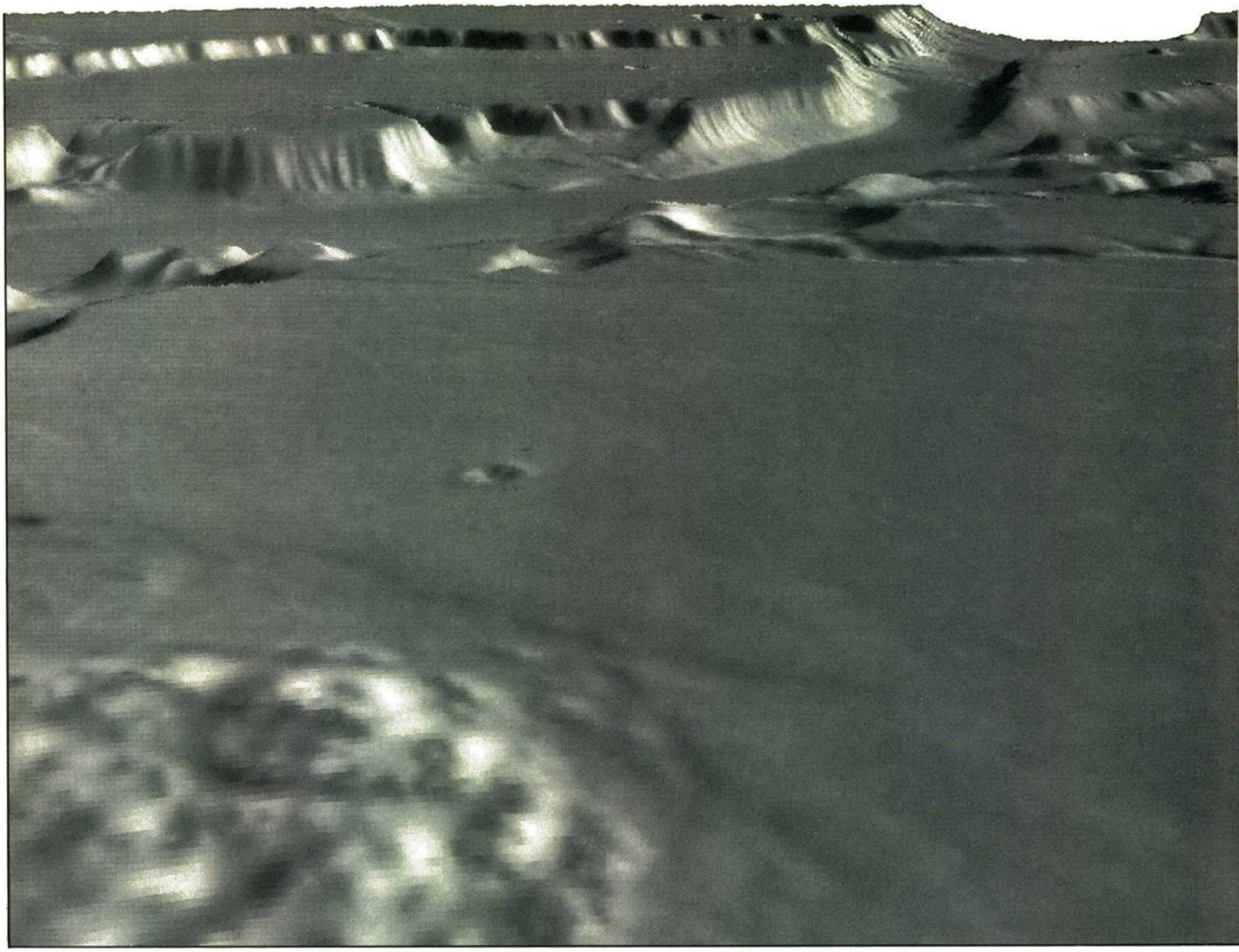
THE FRETTED NETWORK of valleys in Sacra Fossae, about 3,200 feet deep, was produced when subsurface ice melted and the ground above it collapsed as the melt-water flowed away.

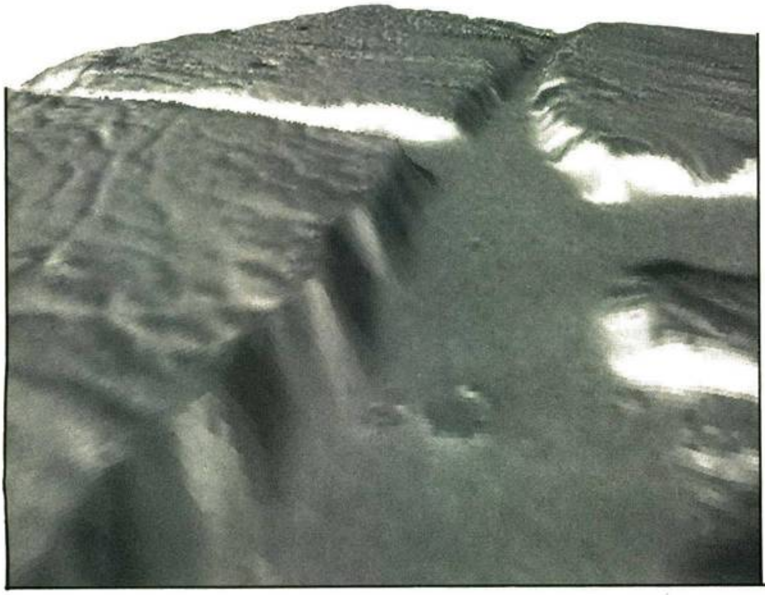


A CLOSE-UP ON SACRA FOSSAE shows the valley system merging smoothly into the southern channel.







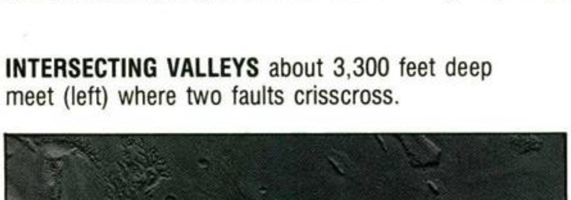


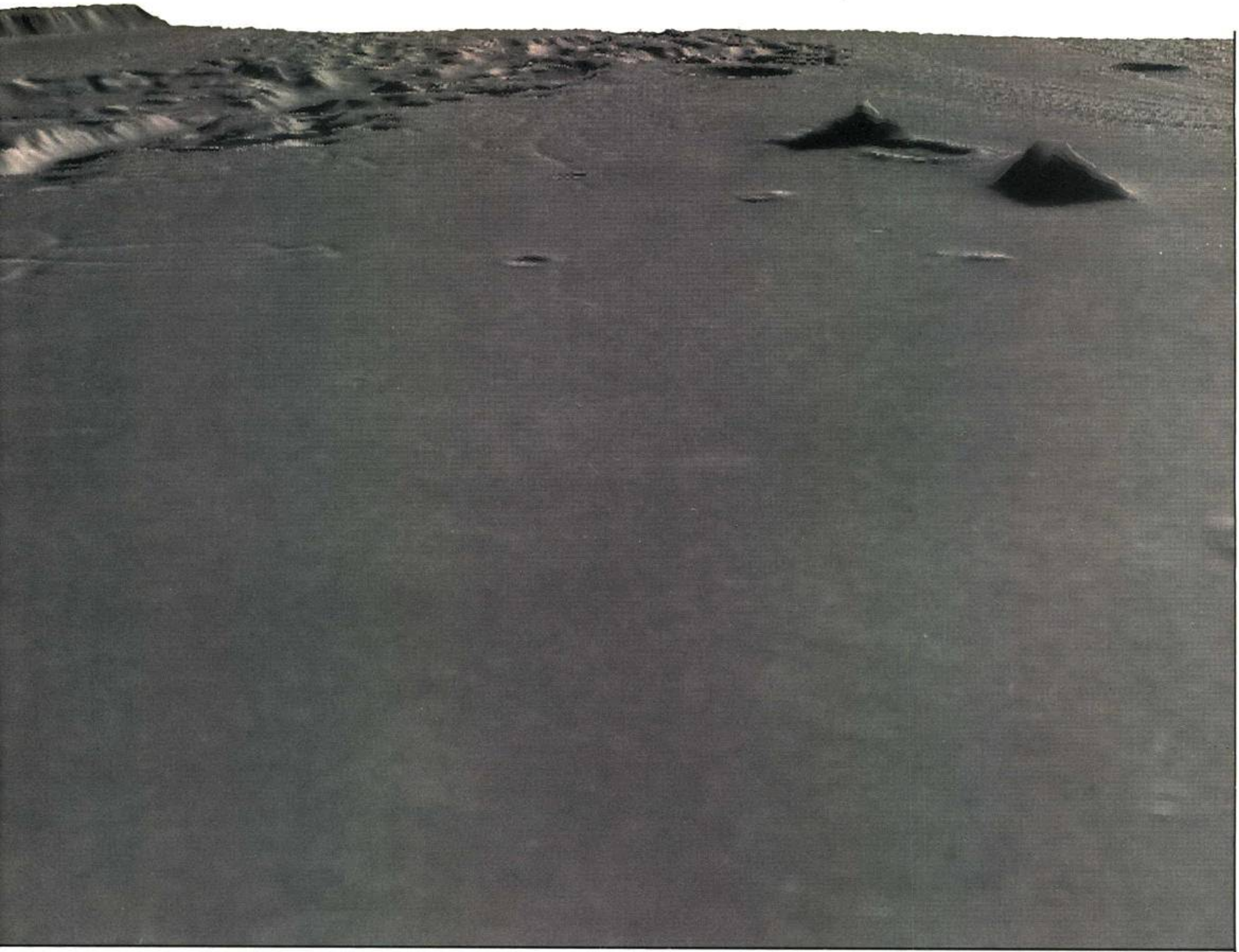
that created the Channeled Scablands in eastern Washington state. The flood (or floods) probably raced along at speeds of roughly 100 miles an hour with an average depth of about 1,000 feet.

The second purpose involved creating the dramatic views seen here. Using special image-processing software at the University of Alaska, I could tell the computer to take the digital Kasei Valles and display it as seen from any viewpoint. (In the pictures the vertical dimension has been exaggerated two times to make the erosional relief features stand out more clearly.)

Although the views are a striking by-product of the flood research, they are much more than just pretty pic-

INTERSECTING VALLEYS about 3,300 feet deep meet (left) where two faults crisscross.

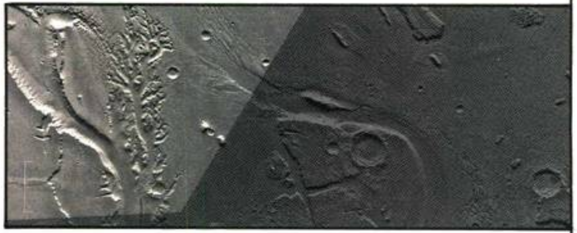




tures. Geologists doing fieldwork on Earth soon become skilled in interpreting landscapes by examining them on foot. But with extraterrestrial geology, this vital third dimension is missing. In the case of Mars, because nearly all of *Viking*'s images were taken with the camera aimed vertically, geologists cannot view Martian landscapes as they would actually look to someone at or near ground level.

The computer offers an ideal way to circumvent this limited perspective and display the valley in a normal way. Notice, for example, how the straight-down view from overhead (pages 38-39) becomes much less abstract and far more real when you see it as if you are looking out of the window of an airplane. To anyone interested in seeing and interpreting its geology, these perspective views of Kasei Valles are vital because they let you discover and trace relationships among features that may be important, such as where the steep clifflike valley walls give way to a gentler talus slope of broken rock.

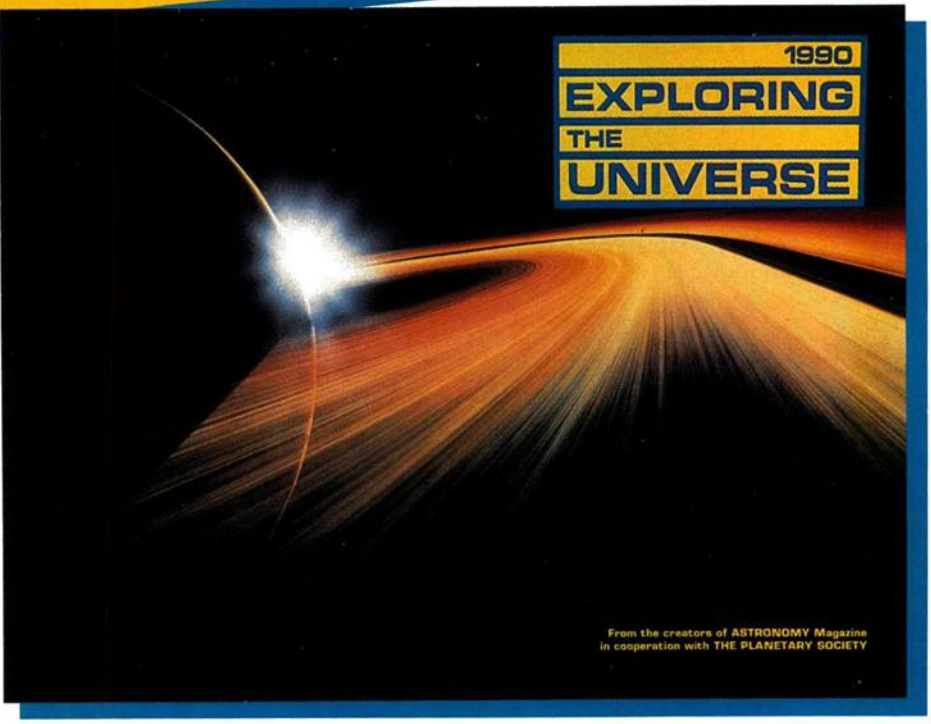
Kasei is one of a very few places on Mars with detailed elevation data. However, the *Mars Observer* spacecraft, scheduled for launch in 1992, will carry a laser altimeter to provide high-resolution elevation data for the most interesting areas of Mars. When this is combined with *Mars Observer*'s best photos from orbit (about ten times sharper than *Viking*'s), the result will be detailed "surface views" far exceeding what's seen here. I don't know about you, but I can hardly wait. ☐



LOOKING BACK UPSTREAM, the southern channel (left background) appears to be eroded much more deeply than the valleys of Sacra Fossae (center background). This view clearly shows the faulted or eroded shelf bordering the valley (upper left).

Mark S. Robinson is a graduate student working with Peter Mouginnis-Mark in the University of Hawaii's Planetary Geoscience Division. His research centers on Martian geology.

Begin each day with a journey into space...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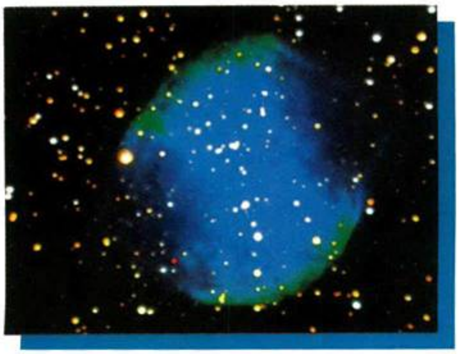

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Night Shield™

The unique design of the Night Shield™ solves three annoying problems for telescope owners.

- It protects the front element of a telescope from the formation of condensation or dew
- It is **collapsible** so that you may store it in the telescope case
- Indestructable and inexpensive

3.5"/4"	$29	11"	$69
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Ask yourself why you would pay more for any other dew shield that won't even fit in your case!

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- Individually hand-tested with an interferometer to ensure the highest quality
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Celestron SPC-8 w/Star	$1195
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Meade 2045-D

Meade Instruments has finally released the long awaited 2045-D. The only 4" Schmidt-Cassegrain with fork mount motor drive in production today.

The Meade 2045-D is perhaps the most versatile telescope currently made. This precision 4" Schmidt-Cassegrain offers excellent planetary and deep-sky enjoyment while remaining ultra-portable. The current model comes with a DC battery pack so you won't need to worry about extension cords or power supplies.

Amaze yourself with just how simple it is to use this exceptional instrument for astronomy, wildlife or photography $695

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Meade	
226 60mm w/Altazimuth mount	$159
291 60mm w/Equatorial mount	$349
312 80mm w/Altazimuth mount	$489
323 80mm w/Equatorial mount	$539
826C 8" w/Equatorial mount	$895
DS-10A 10" w/Equatorial mount	$995
DS-16A 16" w/Equatorial mount	$1989
Vixen	
3305 60mm w/HD Altazimuth mt	$219
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9930 5" Polaris mt newtonian	$499
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Accessories

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#1A Skylight Filter/Dust Seal	$49
1.25" Colored Filters	$15
#908 1.25" Nebular Filter	$69
Meade Series 4000 Eyepieces	Call
C5/C8 Motorized Focuser	$85
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LUMICON FOR HIGH PERFORMANCE

ASTROPHOTO OF THE MONTH

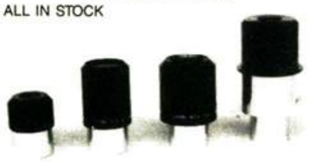
The "Dumbbell Nebula," M-27 in Vulpecula. The "ears" of the Dumbbell are seen best visually with a Lumicon UHC Filter. Photo by David Healy using a Lumicon Giant EASY-GUIDER and Lumicon hypersensitized 2415 film, 30 min., C-14 at f/6.

20mm NAGLER

Also new 12mm & 16mm NAGLERS

TELE VUE™ EYEPIECES USE THE BEST!!

ALL IN STOCK



Genesis 4" f/5.5 Fluorite Apochromat	$1395
Renaissance 4" f/5.5. Telescope	$1395
7.4, 10.4, 13, 17, 21, 26mm **Plossl,** 50°	$89
1.8X or 2.5X Tele Vue Barlow Lens	$89
32mm Plossl, widest true field in 1¼"	$109
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15mm Wide-Field, 1¼" eyepiece, 65°	$129
19mm Wide-Field, 1¼" eyepiece, 85°	$139
24mm Wide-Field, "superb," 65°	$159
32mm Wide-Field, 2" eyepiece, 65°	$229
40mm Wide-Field, "awesome," 65°	$289
4.8mm Nagler, 82° field	$149
7mm Nagler, 1¼" eyepiece, 82° field	$185
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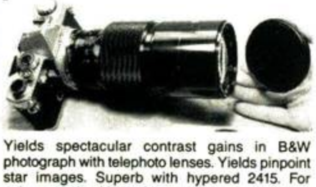
13mm Nagler, 82° field, 1¼" or 2"	$249
12mm Nagler, Type II, 82°, 1¼"/2"	$249
16mm Nagler, Type II, 82°, 1¼"/2"	$299
20mm Nagler, Type II, 82°, 2" only	$340

ADJUSTABLE PIGGYBACK MOUNT

The LUMICON adjustable piggyback mount is ideal for telescopes of 6-16" aperture. It permits **both** vertical and sideways adjustment for optical alignment. Also ideal to mount LUMICON 80mm SUPER-FINDER™, large telephoto lenses and small telescopes up to about 5 lbs.
LUMICON Adjust. Piggyback Mount .. $54
Specify telescope size: 6", 8", 10", 11", 14", 16"

H-ALPHA PASS FILTER



Yields spectacular contrast gains in B&W photograph with telephoto lenses. Yields pinpoint star images. Superb with hypered 2415. For color, use the Minus Violet (MV) Filter.

Specify Lens Size	H-Alpha	(MV)
46, 48, 49mm	$39.00	$34.00
52, 55, 58, 62mm	$49.00	$39.00
67, 72, 77mm	$59.00	$49.00
82mm	$69.00	N/A

Hypered 2415 film, 36 exp .. **$10.95, $3/$29**

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NEW! ENHANCED ALUMINUM DIAGONAL MIRRORS BOOST TELESCOPE PERFORMANCE

LUMICON 1.3" & 2.1" enhanced aluminum diagonal mirrors & 1¼" star diagonal.

The new LUMICON diagonal mirrors have a special enhanced aluminum coating with a protective overcoating for long life. Visible reflectivity is 94-96% compared to 86-89% for standard aluminum coated mirrors. 1.3-1.8" mirrors have enhanced silver coatings (98-99%R). the extra 8-12% transmission is like adding an inch of aperture! The substrate is fine annealed Pyrex flat to 1/8 wave.

1.32"	**$29.95**	1.52"	**$34.50**	1.83"	**$39.50**
2.14"	**$49.50**	2.60"	**$65.00**	3.10"	**$89.50**
4.25"	**$149.50**				

ENHANCED SILVER STAR DIAGONAL

90° star diagonals with 98-99% reflectivity enhanced silver mirrors in a CNC machined black anodized aluminum body. Performance far exceeds prism diagonals.

1¼" (1.32" mirror)	**$99.50**
2" (1.83" mirror)(see photo above)	**$159.00**

LUMICON FILTERS STOP LIGHT POLLUTION

UHC Filter™

ULTRA HIGH CONTRAST

The **LUMICON UHC FILTER** is specially designed for visual astronomy in areas of severe light pollution or for viewing very faint nebulae at any location. **UHC** stands for **U**ltra **H**igh **C**ontrast and this filter is guaranteed to yield a higher visual contrast on planetary and emission nebulae than any other filter at any price. 24nm visible bandpass, 482-506nm. Transmission = 90-97%.

"I CAN SEE THE VEIL NEBULA!"

Rich Zepernick saw the Veil Nebula for the very first time with a LUMICON UHC Filter. He stated, *"It was actually there! and not just around 52 Cygni, but the whole loop! Words cannot possibly express my feelings. I don't know how I managed without these filters."*

Zepernick, Cresskill, NJ

For optimum astronomy, use either the **LUMICON DEEP-SKY Filter or the LUMICON UHC Filter**

DEEP-SKY FILTER™

The **LUMICON DEEP-SKY FILTER** improves your view of **all** deep-sky objects including galaxies and comets. It removes natural and man-made light pollution and yields 3-6x contrast gain for nebulae and 1-3x contrast gain for clusters and galaxies. It is ideal for **both** visual use and B&W or color photography. This gentle filter yields the most natural view of any LPR filter available today. 90nm visible bandpass. 442-532nm. H-Alpha 656nm transmission = 85-95%. Visible transmission = 85-95%.

	Premium*
0.96" LUMICON DEEP-SKY Filter threads into most 0.96" eyepieces	$59.50
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2" LUMICON DEEP-SKY Filter (1.5" aperture), threads into most 2" eyepieces. Also has male & female camera T-threads for prime focus photography	$119.50
72mm LUMICON Giant DEEP-SKY Filter (62, 67, 77mm adapter, $8)	$299.50
1¼" LUMICON UHC Filter threads into most 1¼" eyepieces	$99.50
48mm LUMICON UHC Filter (1.75" aperture) fits most 2" eyepieces	$199.50
Set of Both premium **DEEP-SKY** and **UHC Filters** (Save 11%), Premium	$159.50
LUMICON H-BETA Line Filter (9mm bandpass at 486nm). For the California Nebula, Horsehead Nebula, and other extremely faint nebulae. **1¼"** **$99.50, 48mm**	$199.50
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Telephoto lens adapter for 2" or 48mm filter. Select 46, 49, 52, 55, 58mm	$6.95
Universal adapter for 1¼" filters. Adapts the 1¼" filters to any 1¼" eyepiece	$16.00
Universal adapter for 48mm or 2" filters. Allows use of any 1¼" eyepiece	$20.00

**Premium filters are selected best of the lot and typically have 5-10% higher transmission. Not always available. Include individually measured transmission data.*

DEEP-SKY ASTROPHOTOGRAPHY

SR-V 3200 NEW FILM

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LUMICON HYPER-KITS™ yield 3-15x film speed gain in long exposures. They are safe & simple to use. Easy HYPER-KIT includes a chamber with all controls and fittings, thermometer, a refillable cylinder of non-flammable forming gas & hand-operated vacuum pump.

U.S. Patent 4,473,636

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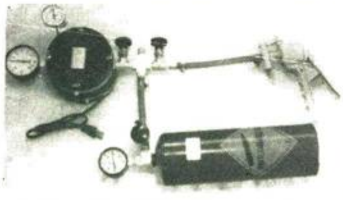
MODEL 300 HYPER-KIT sensitizes any 35mm film in hours. Best for 2415. Achieves highest possible film speeds **$295**



MODEL 600 HYPER-KIT (See photo) Like the Model 300, but also sensitizes 120/220 larger format film and small glass plates **$350**

MODEL 1200 HYPER-KIT is for 4X5" plates and film up to 5X7". Has 2 gas cylinders and includes temperature controller ... **$595**

Temperature controller for any HYPER-KIT **$65**

Electric Vacuum Pump, Model R-10 **$295**

GUIDE OFF-AXIS FOR LOVELY ASTROPHOTOS

All **LUMICON EASY-GUIDER™** off-axis guiders† have both radial and 360° rotational adjustments for 5X easier guide-star selection, use 48mm filters, 360° camera rotation, large prisms for bright guide-stars.
Specify Camera and Telescope type.
U.S. Patent 4,448,500

NEWTONIAN EASY-GUIDER™

Full aperture. Installs in seconds. Specify 2" or 1¼".

NEWTONIAN EASY-GUIDER	**$169.50**
3X Relay Diagonal (see photo)	**$89.50**
Illuminated reticle eyepiece system	**$99.50**

Guider for Hasselblad **$350,** Mamiya 645 **$199**

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For C-8, Meade 2080, Cynamax-8. Includes 50mm achromatic lens for f/5.8 operation—3X shorter exposures! **Superb rich field viewing, too!**

CASSEGRAIN EASY-GUIDER **$225.00**
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For Celestron-11, C-14, and the 10" Meade 2120. Includes 80mm clear aperture achromatic lens for edge-to-edge illumination & pin-point star images. F-ratio adjustable f/4-f/11. **Also yields unmatched Rich-Field viewing.**

GIANT EASY-GUIDER **$395.00**
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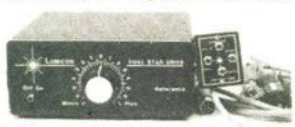
Adapter for Hasselblad **$195,** Mamiya **$96**

WHAT DO YOU NEED?

1. Illuminated reticle eyepiece **$99.50**
Lumicon 12mm eyepiece system has adjustable LED illumination, dual crosslines, battery pack.

2. Cable release for long exposures .. **$9.95**



3. **LUMICON Quartz Drive Corrector . $219**
Dual-axis drive corrector is essential for astrophotography and/or field use of your telescope. 40Hz/80Hz variable output controls telescope drive. 60Hz Quartz reference ±12VDC Declination control output. Both 110VAC and 12VDC input for home or field use. Declination reverse switch for Newtonians.
Declination motor (state telescope) .. $99
NEW Deluxe Digital Qtz. Drive Correc. **$298**

NEW
SRV3200

HYPERSENSITIZED FILM

LUMICON Hypersensitized film is essential for good deep-sky astrophotography. Deduct 10% for 3 or more rolls (mixed o.k.).

Film Type, 35mm	Exposures	Price
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SRV3200, fastest of all, color neg	24	$13.95
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3M 1000, fastest slide film	12	$12.95
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LUMICON® SKY VECTOR™- *NEW!*

Computer-Controlled Digital Setting Circles, only $498

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LUMICON SKY VECTOR™ computer, showing digital readout of coordinates, and easy-to-use controls. Shaft encoders are included (not shown). The coordinates are for Minkowski 1-79, a 13th mag. planetary nebula.

The LUMICON SKY VECTOR™ is a computer-controlled digital setting circle system. It represents a breakthrough in both computer performance and low price. To find an object just move the telescope until the coordinates of the SKY VECTOR™ match those of the object desired.

Each LUMICON SKY VECTOR™ includes one computer with digital readout, two precision digital shaft encoders, connecting cables, & mounting hardware (for most popular telescopes). **Specify telescope.**

Incredibly Smart!
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Incredibly Easy!

- Digital right ascension readout to 1 minute of R.A.
- Digital decl. readout to 10 arc-min
- Digital altitude readout to 1°
- Motor drive ***not required!***
- Polar alignment ***not required!***
- Just sight two stars!

The computer's sophisticated program (over 3000 lines of code) determines **everything** from an initial sighting of just two stars!

- **No need** to enter latitude, longitude, sidereal time, date, etc.
- Works **equally well** for alt-azimuth telescopes like Coulter Odyssey and equatorial mounts like C-8, Meade 2080. The computer automatically knows the difference.
- Uses Epoch 2000.0, 1975.0 or 1950.0 coordinates.
- Light weight, only 2 oz. permits mounting near the eyepiece, if desired. Only 2.6"x2.6"x1".
- 9V Battery lasts many nights.

LUMICON SKY VECTOR™ for Meade 2080,2120,C-8,C-11, *(Specify)*	**$498**
For Celestron-14 .. **$575.** For any alt-azimuth (Dobsonian) telescope	**$498**
For Coulter Odyssey 8", 10", 13", 17½" *(Specify telescope)*	**$498**
SKY VECTOR KIT. You must supply adapting hardware. For skilled ATM's only	**$449**

Reference catalogues listing coordinates of 1000's of objects

Burnham's *Celestial Handbook*, Vol. I, II, III (Epoch 1950.0)	**$36.85**
The *Revised New General Catalogue* (all NGC and IC, Epoch 1975.0)	**$35.00**
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COMA CORRECTOR

Coma 1 inch off-axis 17½" f/4.5

Same field with LUMICON coma corrector; smaller, more numerous stars.

This computer-designed LUMICON 2" lens reduces coma and flattens the field for both viewing and photography. It threads into LUMICON 2" EASY-GUIDERS for effortless installation. This lens is optimized for f/4.5 and reduces aberrations for f/3.5 to f/5 Newtonians. Off-axis images are much smaller, making off-axis guiding far easier and yielding round pinpoint star images in photos. Since star images are sharp over a full 2¼" circle, you can use medium format cameras in addition to 35mm cameras. This zero power lens does not change image scale nor shift focus, and all lens surfaces are multi-coated for highest efficiency. Although designed for photography you may also use this lens to improve image quality in wide-field viewing with low power eyepieces.

LUMICON Coma Corrector/Field Flattener Lens	**$285.00**
LUMICON 2" EASY-GUIDER	**$169.50**
2" EASY-GUIDER (Mamiya 645)	**$199.50**
2" Adapter for Pentax 6x7	**$85.00**
2" Adapter for Hasselblad	**$185.00**
2" Adapter for Bronica SQ-A	**$175.00**
2" Extension for viewing	**$26.00**

1.5x, 1.8x MULTIPLIER LENS

1.8x Multiplier Lens

The computer-designed LUMICON 2" Multiplier/Field Flattener multiplies the image scale in photography by 1.8x (f/4.5 becomes f/8). Use it with any LUMICON 2" EASY-GUIDER. It multiplies by 1.5x without the included extension tube. This lens is optimized for f/4.5, but will work well with any optical system. It may also be used visually as a highly corrected 2" Barlow lens.

LUMICON 1.5x/1.8x multiplier lens **$235.00**

NEW! LOW PROFILE HELICAL FOCUSERS

FROM
$49.50

LUMICON® LOW PROFILE FOCUSERS

LUMICON now offers 3 different low-profile helical focusers. They stand only 1¼-1½" above the telescope tube. Use the 1¼" or 2" versions for viewing. Use the 2" non-rotating focuser for convenient photography with the LUMICON 2" EASY-GUIDER™.

Select your desired base-plate shape! Flat, 7" OD, 9½" OD, 12½" OD, 16" OD, 21" OD, SUPER-FINDER base plate.

LUMICON 1¼" Helical Focuser	**$49.50**
LUMICON 2" Helical Focuser	**$59.50**
LUMICON Non-rotating Helical Focuser	**$89.50**
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2" LUMICON EASY-GUIDER	**$169.50**

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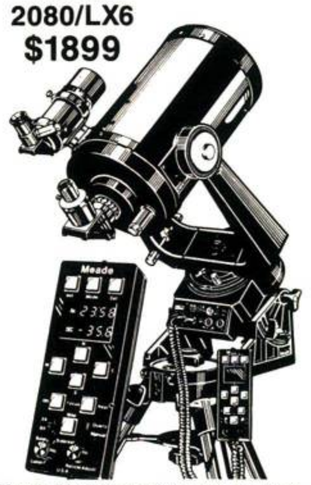
LUMICON ACCESSORIES

2080/LX6 8" f/6 .. $1899
2120/LX6 10" f/6 . $2499

Digital readout system for 2080/2120/LX6	**$399**
8200 object memory CAT computer	**$999**

NEW 2080/LX6 $1899



Meade Model 2080/LX6: The most advanced Schmidt-Cassegrain telescope available today. The hand-held electronic command center controls all telescope functions, and has digital coordinate readout available as an option. The f/6.3 optics yield 2½x shorter exposures in astrophotography.

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Super Plossl: 6.4mm, 9.7mm, 12.4mm **$89** 15mm, 20mm, 26mm **$89;** 32mm **$109**
Super Wide-angle: 13.8mm **$129,** 18mm **$135,** 24.5mm **$149,** 32mm (2") **$219**
Ultra Wide-angle: 4.7mm **$149,** 6.7mm **$179,** 8.8mm **$209,** 14mm **$249**

SCHMIDT-CASSEGRAIN

2080 Original 8" f/10 w/tripod	**$999**
2080/LX3, 8" f/10 w/MCOG	**$1389**
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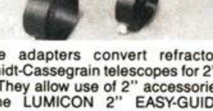

These adapters convert refractors and Schmidt-Cassegrain telescopes for 2" operation. They allow use of 2" accessories, such as the LUMICON 2" EASY-GUIDER for photography. They also allow use of 2" eyepieces and/or 2" star diagonal for viewing.

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A Life Devoted to Astronomy

From eclipse chasing to teaching, Charles Burckhalter's enthusiasm for astronomy left its mark on Oakland, California.

by Katherine Bracher

The sky darkened rapidly. It was early in the afternoon on New Year's Day, 1889, and a group of two dozen amateur photographers and their assistants eagerly awaited the approaching shadow of the Moon. As the last vestiges of sunlight disappeared from the sky over northern California, the photographers made their final preparations.

Suddenly the Sun's corona flashed into view. The group burst into activity, taking photos of the total solar eclipse with a wide variety of lenses and exposure times. Then just two minutes later, a beam of sunlight peeped from behind the Moon and totality was over. Cheers and shouts of celebration rang out over the field, mingled with expressions of awe from the people who had just witnessed the impressive sight.

Charles Burckhalter breathed a deep sigh of relief. As leader of the expedition, he had conceived and organized the trip to the small town of Cloverdale, California, to photograph the total eclipse. Now that the eclipse was over, Burckhalter relaxed. Everything had gone as planned and the photographs they had taken would prove valuable to astronomers studying the Sun.

Burckhalter was not a professional astronomer himself nor was he a photographer. Instead, he was an enthusiastic amateur astronomer who had been named director of Oakland's Chabot Observatory two years before the eclipse. As director of the observatory, he introduced two generations of Oakland schoolchildren to the wonders of astronomy. The success of the 1889 eclipse expedition fostered a cooperative spirit among amateur and professional astronomers that continues today with the support of an organization Burckhalter helped found, the Astronomical Society of the Pacific.

From Small Town to Big Town

Charles Burckhalter was born in 1849 in Taylorsville, Ohio, a small town in the east-central part of the state near Zanesville, but he soon moved with his family to a farm near Ottumwa, Iowa. Shortly after graduating from high school in 1866, Charles moved on to California. There he went to work with his brother Fred, who owned the general store in Truckee, a small mining town not far from Lake Tahoe high up in the clear air of the Sierra Nevada Mountains. It was here that he first developed an interest in astronomy.

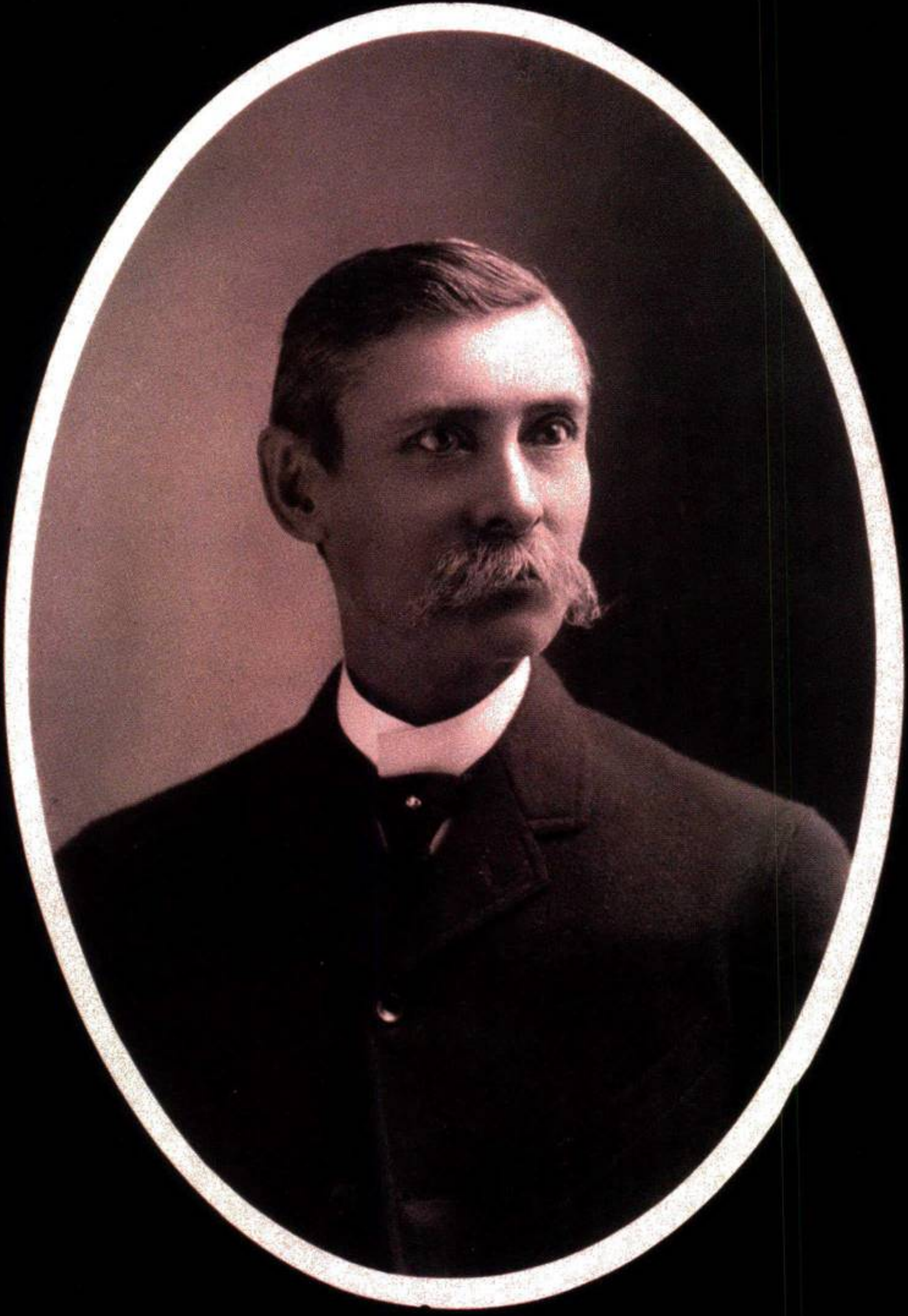
Burckhalter tired of the small town life in Truckee, however, and from there he went on to serve as an oiler on board a ship in the China trade for three months in 1876-77. He was married a year later, and the year after that he and his wife moved to Oakland, California. From there Burckhalter commuted to San Francisco, where he worked as an insurance adjuster for the North British and Mercantile Insurance Company.

In his spare time Burckhalter continued to pursue his interest in astronomy. He honed his observing skills with a 4.5-inch telescope that he kept in his backyard. Like many other amateur astronomers, however, Burckhalter had "aperture fever," and in 1883 he bought a 10.5-inch reflecting telescope from John A. Brashear. He used that telescope to observe the partial solar eclipse on October 30 of that year. This was his introduction to eclipse viewing, and he developed a passion for it that would last the rest of his life.

Although Burckhalter had no formal training or education in astronomy, his years of devoted study made him exceptionally well informed on the subject. In fact, his knowledge was such that in 1885 the city of Oakland appointed him to teach astronomy and geography in the city's only high school. In addition, he was named an assistant at the three-year-old Chabot Observatory, which was located in downtown Oakland and was operated by the City Board of Education. In 1887 Burckhalter became the director of Chabot, a position he retained for the remaining thirty-six years of his life.

Burckhalter was passionate in his efforts to introduce others to astronomy. As director of the observatory, it was often his responsibility to show schoolchildren the Moon, planets, and stars through the observatory's 8-inch refractor. He was happy to satisfy genuine curiosity, but his patience with young children at the evening observing sessions was limited. He once referred to these youngsters as those "whom in a private capacity I devotedly admire, but whom as astronomical students I must unhesitatingly pronounce the measliest failures on record. . . . If the youngsters really learned anything they would remember for five minutes I shouldn't complain, but they don't," and they interfered with the viewing of others. "I know perfectly well I'll commit boyslaughter some of these days, and drop the most obnoxious kid over the railing." However, these feelings were evidently kept in check, and the people of Oakland greatly admired Burckhalter for his efforts on

ASTRONOMER AND EDUCATOR Charles Burckhalter helped launch an era of cooperation between amateur and professional astronomers.



behalf of astronomy education.

Mounting the Expedition

In 1888 Burckhalter read a pamphlet written by Edward S. Holden, director of the new Lick Observatory on Mount Hamilton, entitled *Suggestions for Observing the Total Eclipse of the Sun on January 1, 1889*. In the pamphlet Holden pointed out that the path of totality passed through northern California (north of San Francisco) and suggested several important observations that amateurs and the general public could make. One of these suggestions was to photograph the eclipse. Although a few people had successfully photographed the eclipsed Sun in the previous two decades, eclipse photography was a fairly new endeavor that promised to increase astronomers' knowledge of the Sun. After reading the pamphlet, Burckhalter conceived the idea of a photographic expedition to some point in the path of totality and sought ways to carry it out.

In October he proposed the plan to the members of the Pacific Coast Amateur Photographers' Association (PCAPA), a group of business and professional men with an interest in photography. Burckhalter attended one of their meetings and gave a talk on "The Services of Photography to Astronomy," placing particular emphasis on eclipse photography. After the talk the photographers, obviously enthusiastic, elected him an honorary member of their association, and some twenty-five of them volunteered to go on an expedition under his leadership. The plan was to photograph the eclipse with an assortment of lenses and a wide range of exposure times. They would then donate the photographs to Lick Observatory. Burckhalter selected Cloverdale in Sonoma County as the observing site because it was near the center line of the eclipse and could be reached easily by train.

The photographers received their final instructions on December 26. They were to catch the 3:30 ferry from San Francisco to Tiburon on December 31 and then take the train from Tiburon to Cloverdale, a total distance of about seventy-five miles. They were told to read Holden's pamphlet carefully and to be prepared to follow Burckhalter's instructions to ensure that they would get good pictures of the most important aspects of the eclipse.

At about 8 p.m. on New Year's Eve, the enthusiastic crowd descended on Cloverdale's lone hotel: "a hungry horde clamoring for rooms and something for the inner man," as PCAPA president Archie Treat later described it. The hotel managed to cope with the party, albeit with some difficulty. Burckhalter held a meeting after dinner to brief the observers on their tasks, but the session lacked the dignity and decorum many people would expect of a scientific expedition. Treat described how "in illustrating the phenomenon of an eclipse, the learned Professor was so unscientific as to represent the approaching Moon by a soft hat and the obscured Sun by a soup plate." The gathering eventually degenerated into an impromptu entertainment of musical selections and dramatic readings. The exuberant photographers, no doubt aided by New Year's Eve libations, wandered through the hotel in high spirits that evening, amusing themselves and terrifying others with such antics as throwing flash powder into open fireplaces.

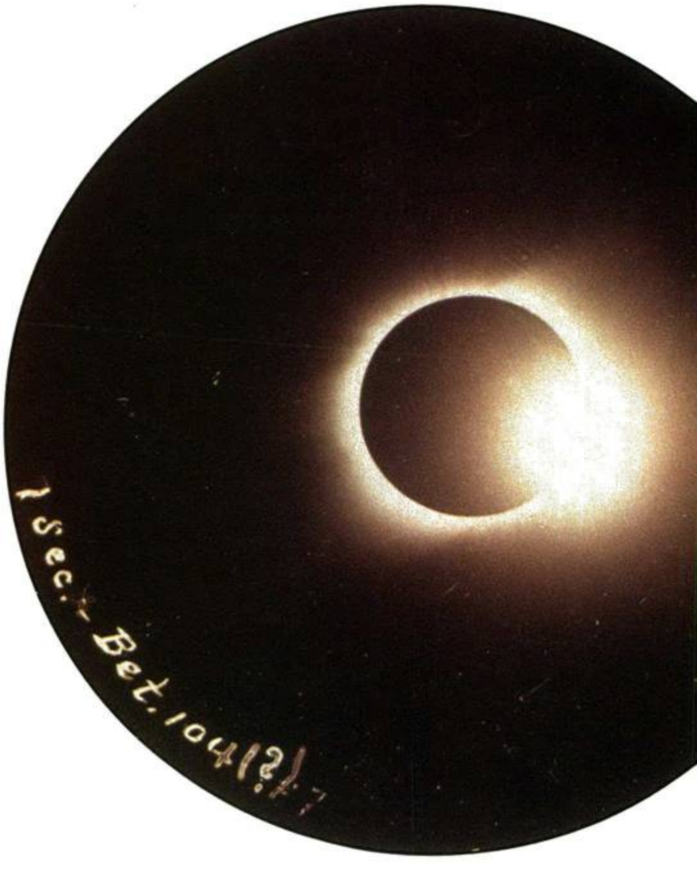
The next day, however, it was back to science. The photographers set up their equipment in the late morning and early afternoon and then waited anxiously for the Sun to disappear. At 1:46 p.m., just as predicted, the Sun's disk slipped behind the Moon and the tenuous corona came into view. For the next two minutes the timekeeper counted down the number of seconds remaining in totality while the would-be astronomers tripped their shutters, changed plates, and recorded the event for science. At 1:48 the corona disappeared as the limb of the Sun peeked out from behind the lunar disk.

In all some sixty-five people participated in the observations — the twenty-four photographers, their assistants and record keepers, and several ladies who sketched the corona and watched the ground for shadow bands. Following totality the observers packed their equipment, had a quick lunch, caught the 3:30 train for home, and arrived back in San Francisco that night.

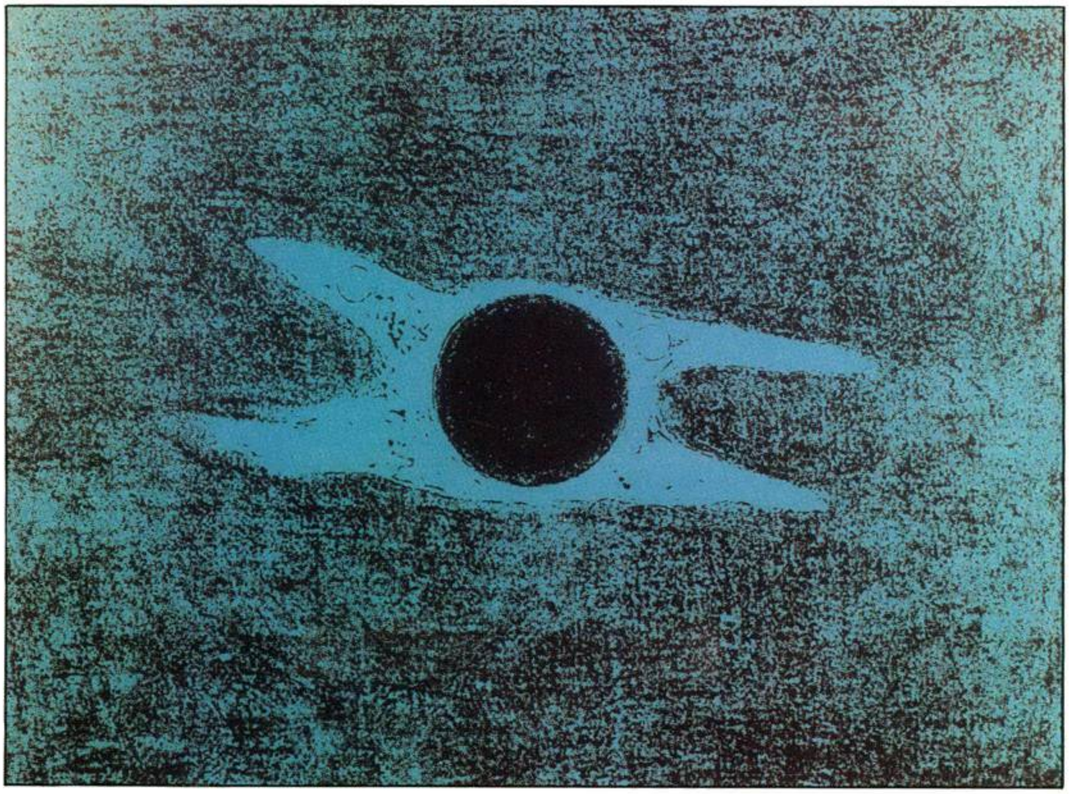
Continuing the Tradition

Burckhalter was pleased with the whole undertaking: everything had gone as he had hoped and worked for. Holden was delighted, particularly when he saw the photographs and detailed report Burckhalter sent to him. (These were later published in No. 1 of the *Contributions of the Lick Observatory*.) Holden was excited by the dedication shown by the amateurs and wrote to Burckhalter: "Certainly the zeal of the members of the association is sure to result in some definite knowledge." He felt that their enthusiasm for making astronomical observations should be encouraged and devised a way to do this.

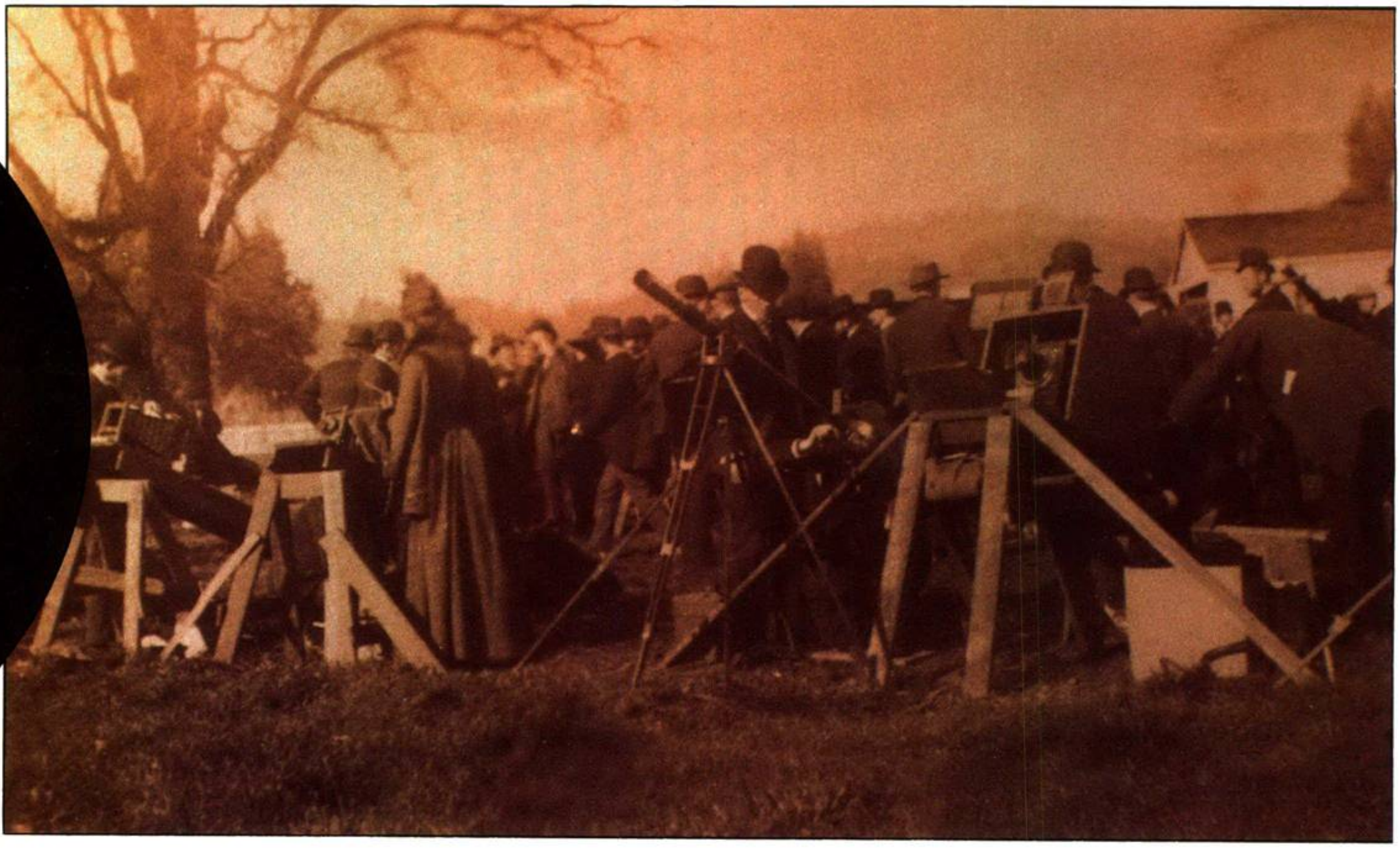
On February 7 Holden and Burckhalter attended a dinner meeting of the PCAPA in San Francisco. Holden addressed the group after dinner, saying in part: "No



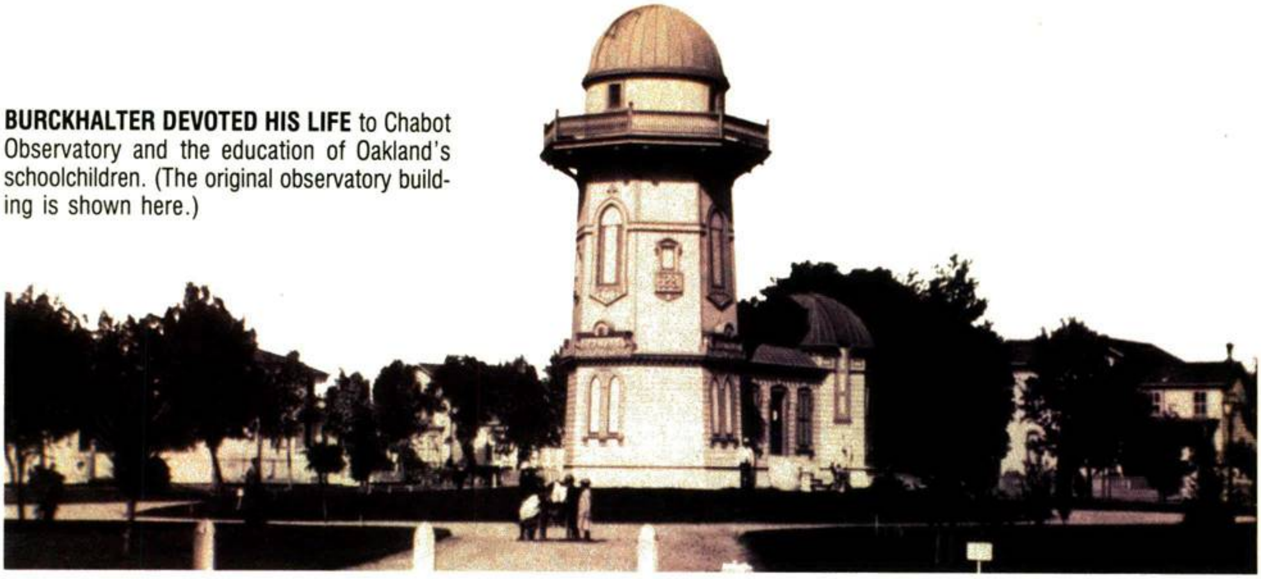
A DIAMOND RING at the limb of the Moon signals the end of totality at the 1889 eclipse.



CORONAL STREAMERS dominate sketches of the total eclipse of the Sun made on the 1889 eclipse expedition.



HOPING TO PHOTOGRAPH the eclipsed Sun, participants in the 1889 expedition set up their cameras and telescopes.



BURCKHALTER DEVOTED HIS LIFE to Chabot Observatory and the education of Oakland's schoolchildren. (The original observatory building is shown here.)

greater service has ever been rendered by photography to science than that recently performed by your Society." He therefore proposed the creation of an Astronomical Society of the Pacific to provide a means for continuing this kind of fruitful cooperation between amateurs and the astronomers at Lick Observatory. The idea generated a lot of enthusiasm — that night a total of forty men signed the Charter Membership Roll: the six Lick Observatory staff members, thirty-three others, mostly PCAPA members, and of course, Charles Burckhalter. The fledgling organization promptly elected Burckhalter secretary of the new society.

Over the years Burckhalter served the ASP loyally, both as secretary in the early years and twice as president (in 1895-96 and 1908-09). He also served on the Board of Directors in most years from the society's founding until 1918. A century later, the society he helped found is still thriving, with over six thousand amateur and professional members worldwide.

Burckhalter's interest in eclipses did not cease with the 1889 eclipse. In 1896 he was a member of a Lick Observatory expedition to Japan and in 1898 he was in charge of a joint ASP and Chabot Observatory expedition to India. Following the latter eclipse he made a round-the-world trip, returning home through the Near East, Jerusalem, Egypt, and Europe. In 1900 he led a Chabot expedition to Georgia for the May 28 total eclipse and took several photos of the corona.

Burckhalter's principal dedication, however, was to Chabot Observatory, and he devoted nearly all of his energies to it. He soon realized that the increasing glare of Oakland's night lighting was creating problems for the observatory, and he began a campaign to move the observatory to a darker location and to acquire a larger telescope. After years of working to interest contributors, raise funds, and persuade Oakland's city government of the necessity of these actions, the city secured an 11-acre site in 1915 on the eastern edge of Oakland and purchased a 20-inch refractor. Burckhalter was delighted with the new telescope — he called it Rachel because he had waited so long for it — and supervised its installation. The 20-inch telescope still resides in Chabot Observatory, just off Interstate 580 in Oakland.

For the next eight years Burckhalter presided over the new Chabot Observatory, overseeing the installation of other buildings and instruments and continuing to educate the schoolchildren and general public of Oakland. His health began to fail in 1923, however, and he submitted his resignation to the Board of Education. Yet the Board would not accept it, suggesting instead that he take the summer off. He did so but returned to Oakland still suffering from heart trouble.

Burckhalter died on September 20, 1923, just three days after a brush fire broke out near Chabot Observatory. Early newspaper accounts reported that Burckhalter rose from his bed to take charge of the fire fighters and save the observatory. His son, however, disputed those accounts in a letter to Robert G. Aitken at Lick Observatory. He wrote that "the press reports of [Charles Burckhalter's] activity in the recent fire which threatened the observatory were exaggerated, as he was confined to his bed at the time, although his anxiety for the buildings probably hastened the end. Among his last words were instructions for the care of the instruments."

Burckhalter's contributions are remembered in Oakland: the city named both a school and a street after him. The Oakland Board of Education also dedicated the 20-inch refractor to his memory. The inscription on a brass plaque at the observatory reads: "He devoted his life to the youth of Oakland that they might know eternal truth as it is written in the stars."

But this formality overlooks the humanness and sense of humor of the man who had inscribed on his bookplate: "Private Library of Chas. Burckhalter. 'The wicked borroweth and payeth not again' — Ps. 37:21." He was amused by newspaper editors who had difficulty spelling his name (among the many variations offered were Barkhalter, Burchhalter, Bardhalter, Brickhulter, Birchhalter, and Buckhalter). And the warmth of his personality is reflected clearly in an Oakland Tribune editorial published after his death, which described him as "a tall man with a kindly smile . . . [who was not] too learned to meet wondering curiosity and ignorance with helpfulness and understanding."

Charles Burckhalter exemplified all the best things that an amateur astronomer can be — a contributor to science, a dedicated teacher, and an advocate of astronomy for the public. That both the Chabot Observatory and the Astronomical Society of the Pacific carry on this tradition today is a fitting tribute to his memory. □

Katherine Bracher is a professor of astronomy at Whitman College in Walla Walla, Washington, and the Chair of the Historical Astronomy Division of the American Astronomical Society.

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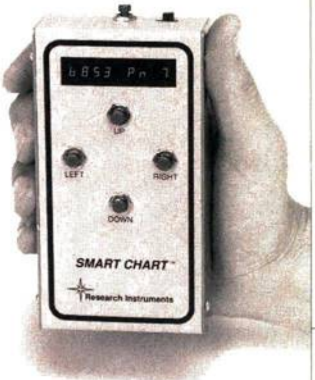

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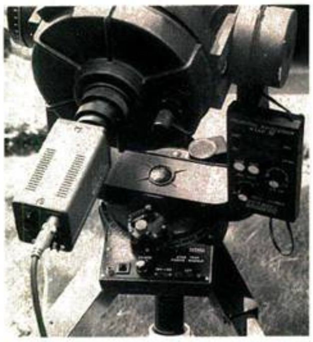

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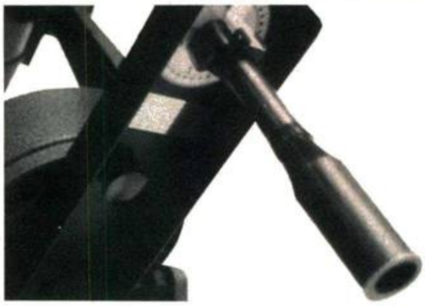

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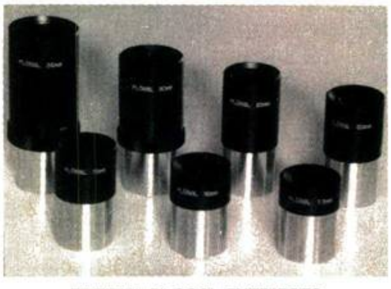

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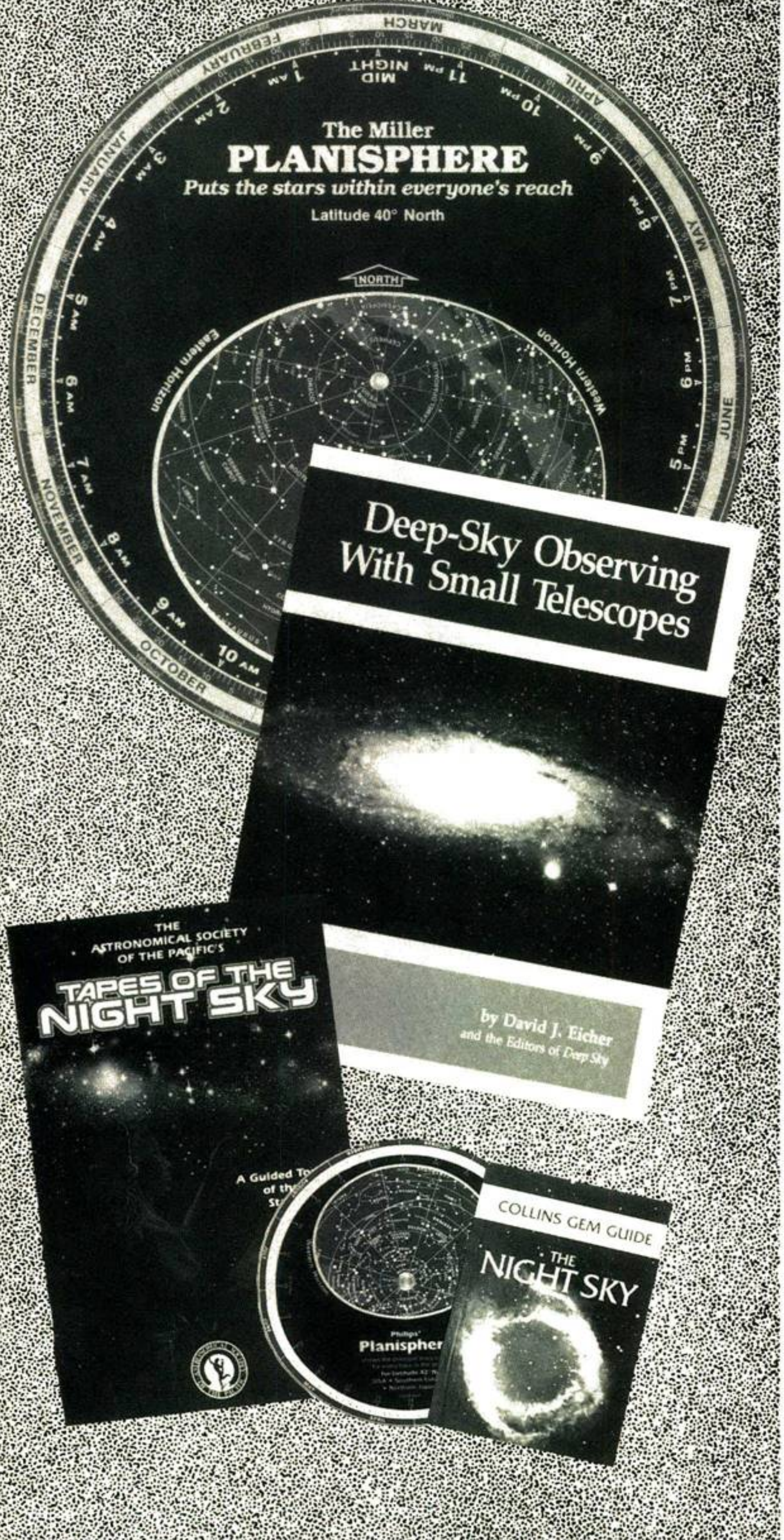
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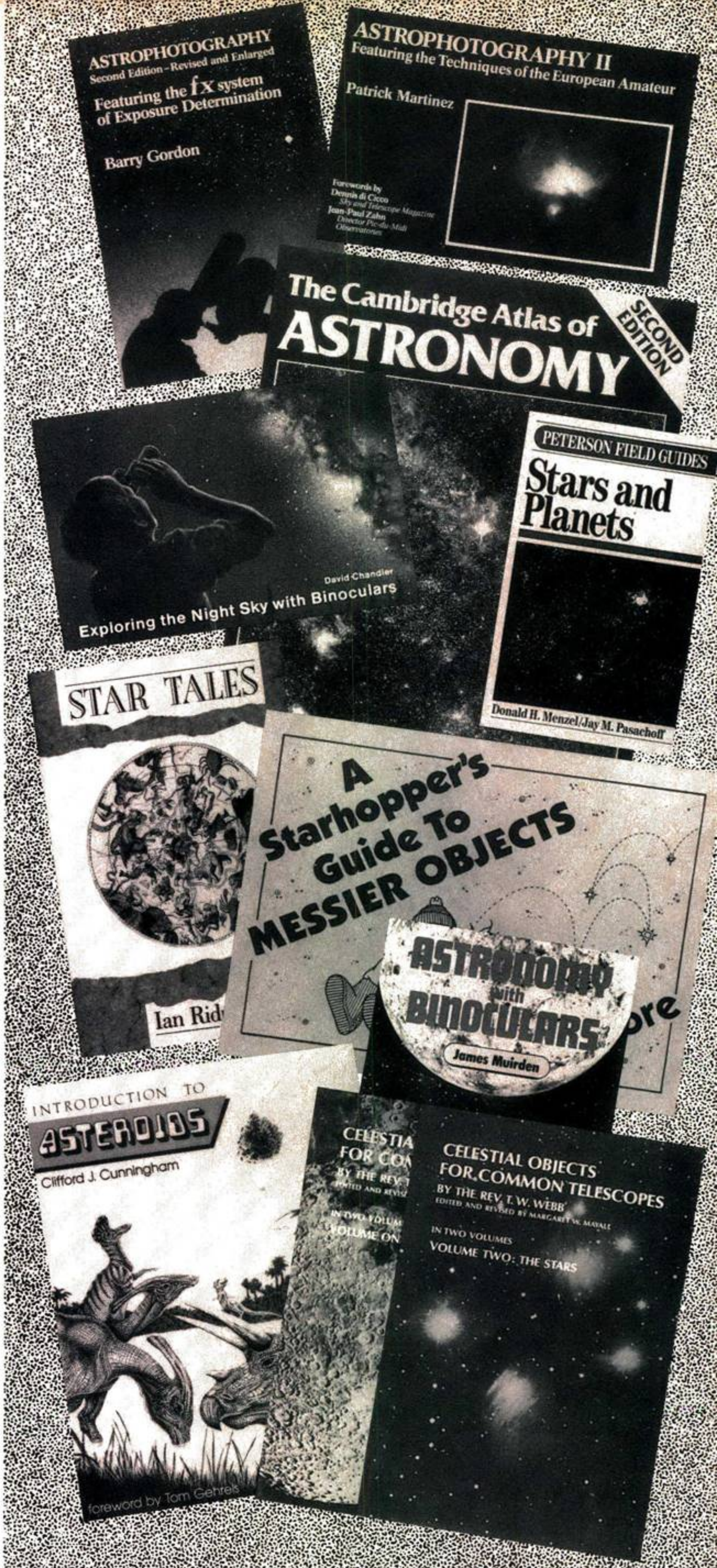
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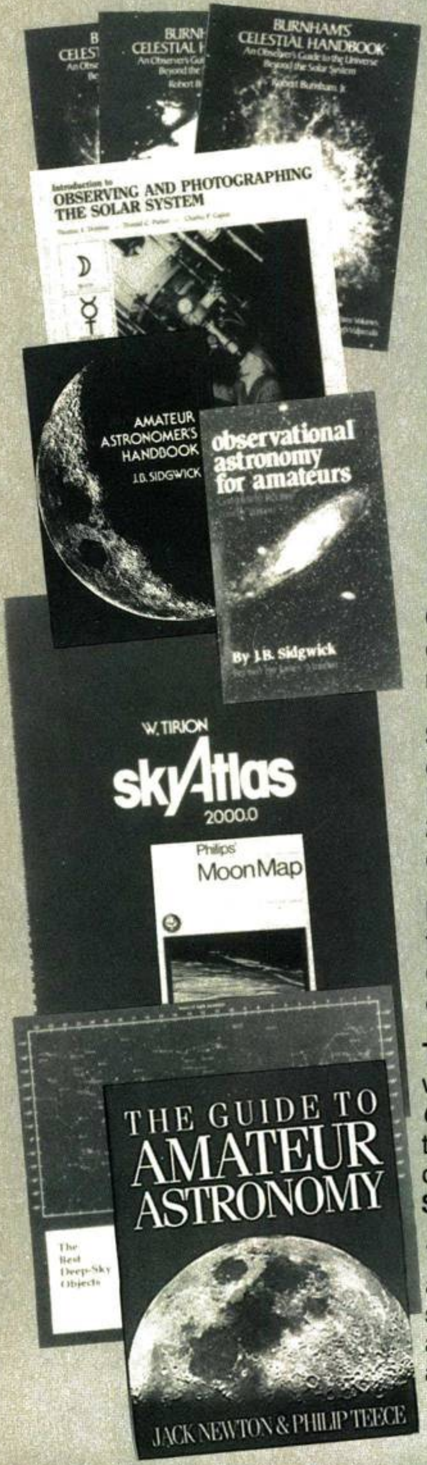

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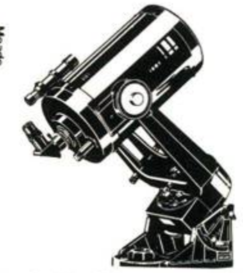

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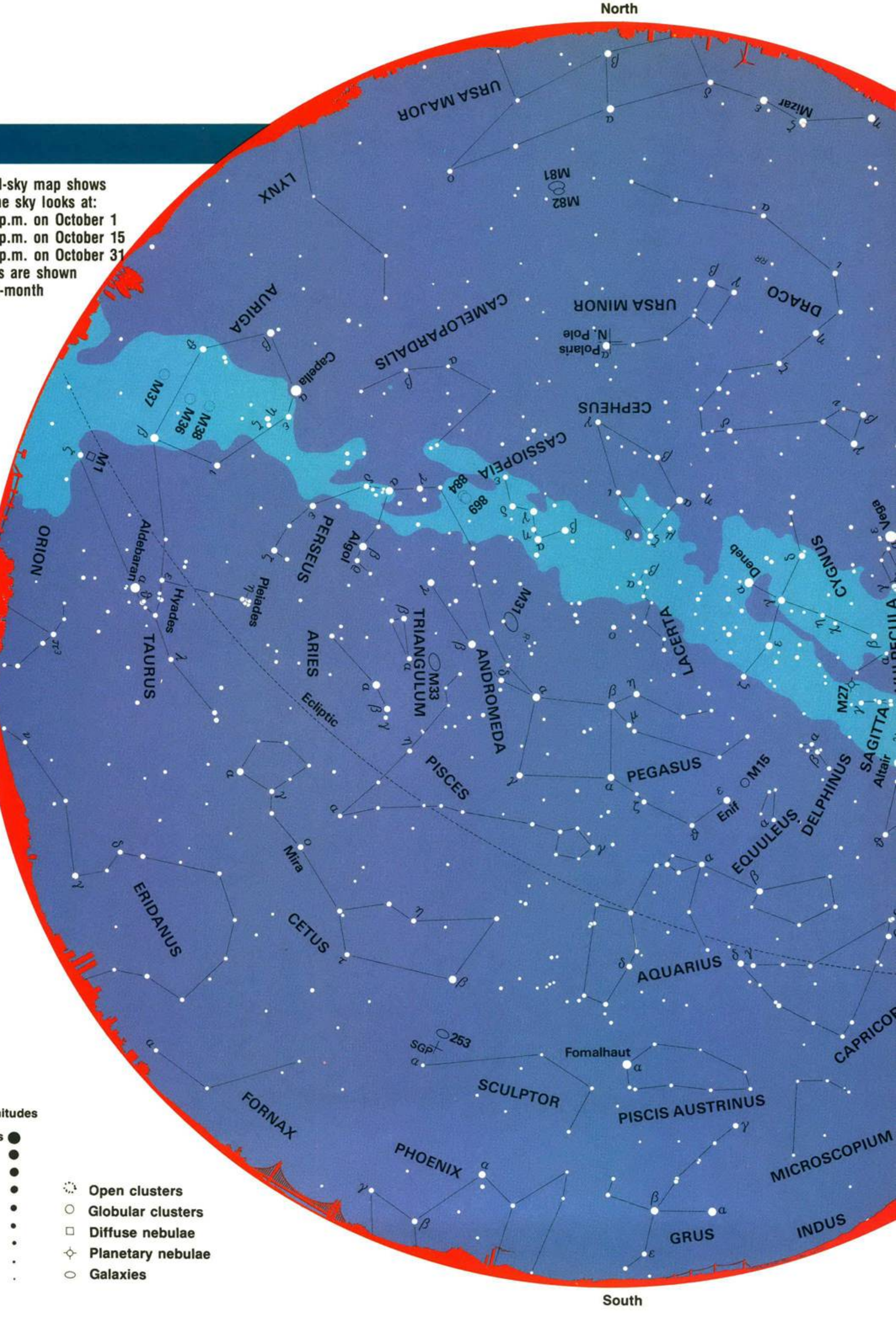
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South
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DRACO
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CAMELOPARDALIS
M37
M36
M38
CEPHEUS
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CASSIOPEIA
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869
ORION
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Hyades
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Open clusters
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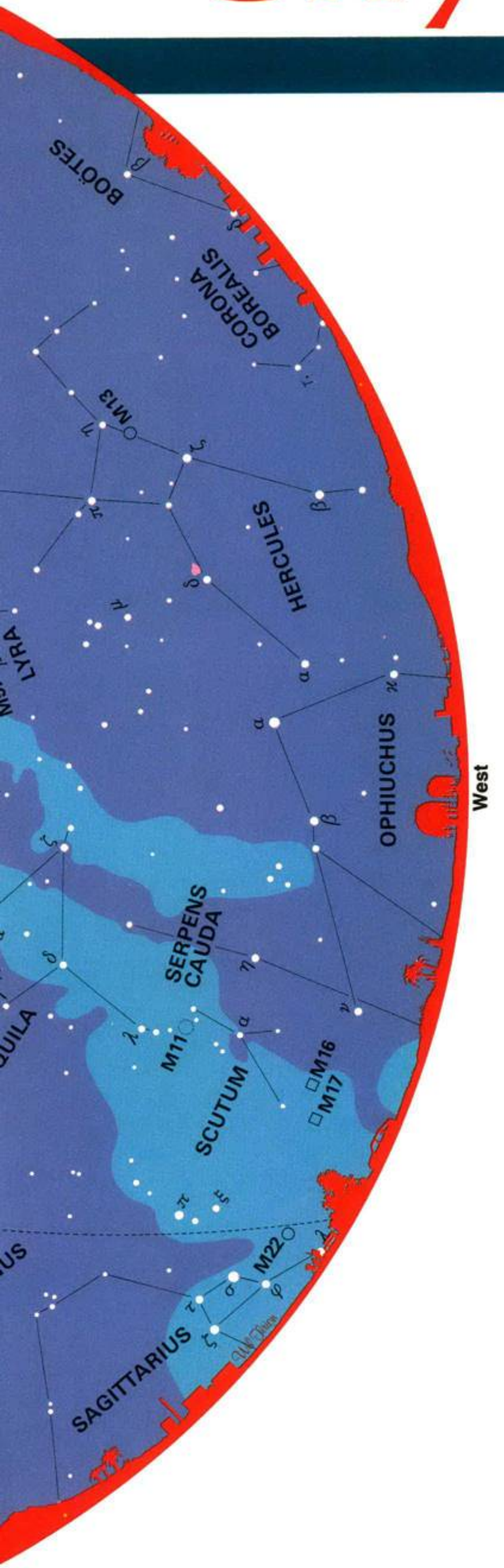
OCTOBER 1989



SPOT MERCURY IN THE MORNING

The elusive inner planet is relatively easy to find in the morning sky this month. Look for it low in the east about forty-five minutes before sunrise.

JUPITER AND ITS FASCINATING MOONS

Now just two months away from opposition, Jupiter and the Galilean satellites offer several interesting events for telescope owners. For the first time in two-and-a-half years, you can see all four Galilean satellites experience eclipses, transits, or occultations with Jupiter.

THE MOON OCCULTS THE BEEHIVE

On the night of October 21/22, viewers in eastern North America can see the waning crescent Moon pass in front of M44, the bright open cluster in Cancer known as the Beehive.

Dates and Times

1 The Moon is at apogee (252,605 miles from Earth), 4:08 p.m. EDT

3 The Moon passes 3° south of Venus, 9 p.m. EDT

5 The Moon passes 0.4° south of Antares, 1 a.m. EDT

7 The Moon passes 4° south of Saturn, 7 a.m. EDT
First Quarter Moon is at 8:52 p.m. EDT

8 Draconid meteor shower peaks

9 Juno is in conjunction with the Sun

10 Mercury is at greatest western elongation (18°)
Urania is at opposition

14 Full Moon is at 4:32 p.m. EDT
The Moon is at perigee (221,651 miles from Earth), 9:19 p.m. EDT

16 Venus passes 1.8° north of Antares, 9 p.m. EDT

20 The Moon passes 4° north of Jupiter, 1 a.m. EDT

21 Last Quarter Moon is at 9:19 a.m. EDT
Orionid meteor shower peaks

22 The Beehive Cluster is occulted by the Moon, 1 a.m. EDT

23 The Moon passes 1.1° south of Regulus, 10 p.m. EDT

25 Mercury passes 4° north of Spica, 7 p.m. EDT

28 The Moon is at apogee (252,674 miles from Earth), 6:21 p.m. EDT
Jupiter is stationary

29 New Moon is at 10:27 a.m. EST

Eye on the Sky by Deborah Byrd

MERCURY BRIGHT IN THE MORNING SKY

October brings an excellent opportunity to see Mercury in the predawn sky. The elusive planet is easiest to see around the time of greatest elongation, which occurs on October 10, when Mercury appears farthest from the Sun. You should easily spot Mercury low in the east approximately forty-five minutes before sunrise. Although the planet is not quite as far above the horizon as it was in the evening last spring, it is brighter now. Mercury shines at magnitude −0.5 on October 10 and becomes even brighter afterward.

The innermost planet lies 18° west of the Sun at greatest elongation. Although 18° is a relatively small separation, this is Mercury's best morning apparition of 1989 because at this time of year the ecliptic — the approximate path of the Sun, Moon, and planets across the sky — stands nearly upright to the eastern horizon before dawn. Thus nearly all of Mercury's 18° separation from the Sun translates into altitude above the horizon and the planet can be seen with relative ease.

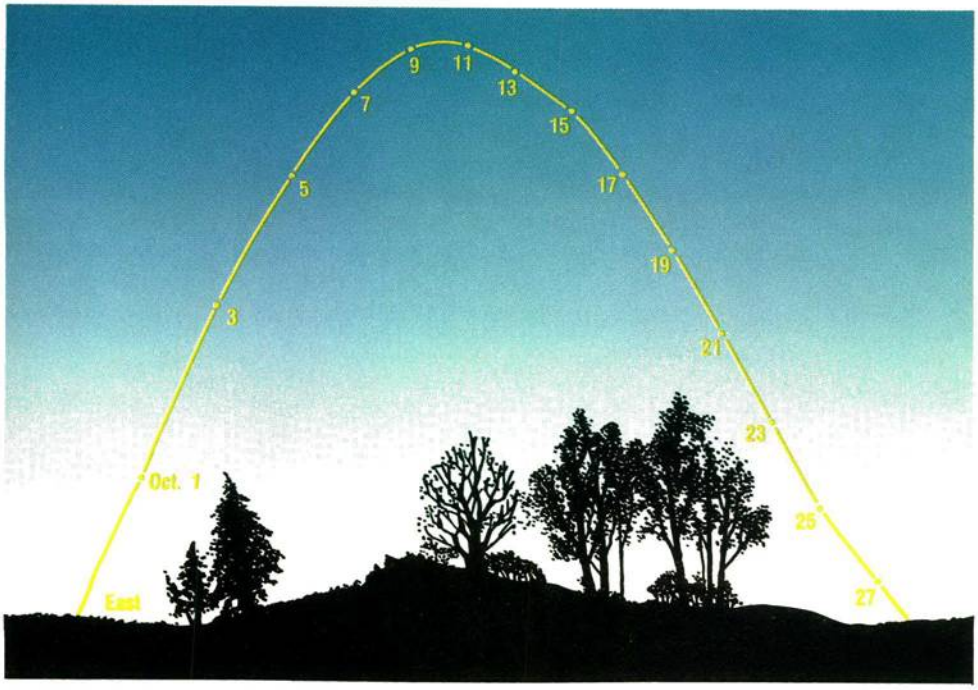
Just two days before greatest elongation, Mercury reaches perihelion, when it is closest to the Sun in its orbit. This accounts for Mercury's small separation from the Sun, and it also means that Mercury travels at its greatest orbital speed at this time. So even though Mercury is well placed for viewing this month, its appearance in the morning sky is short-lived. Mercury comes into view during the first few days of October, shoots up to greatest elongation, then plunges toward the horizon again, where it disappears from view by the end of the month.

SEARCH FOR THE ZODIACAL LIGHT

Early risers this month may glimpse another phenomenon that benefits from the steep angle of the ecliptic on autumn mornings. The zodiacal light, or "false dawn," is an ethereal glow in the east that comes into view about an hour before true dawn begins. The light has a very subtle appearance that any competing light from the Moon or artificial lighting will drown out.

The zodiacal light is shaped like a pyramid; the base of the pyramid rests on the horizon and the apex stretches along the ecliptic. The light comes from sunlight reflected off grains of dust in the inner solar system and is brightest along the ecliptic, where the dust is most dense. Although observing the zodiacal light is a challenge, it's a beautiful sight well worth searching for.

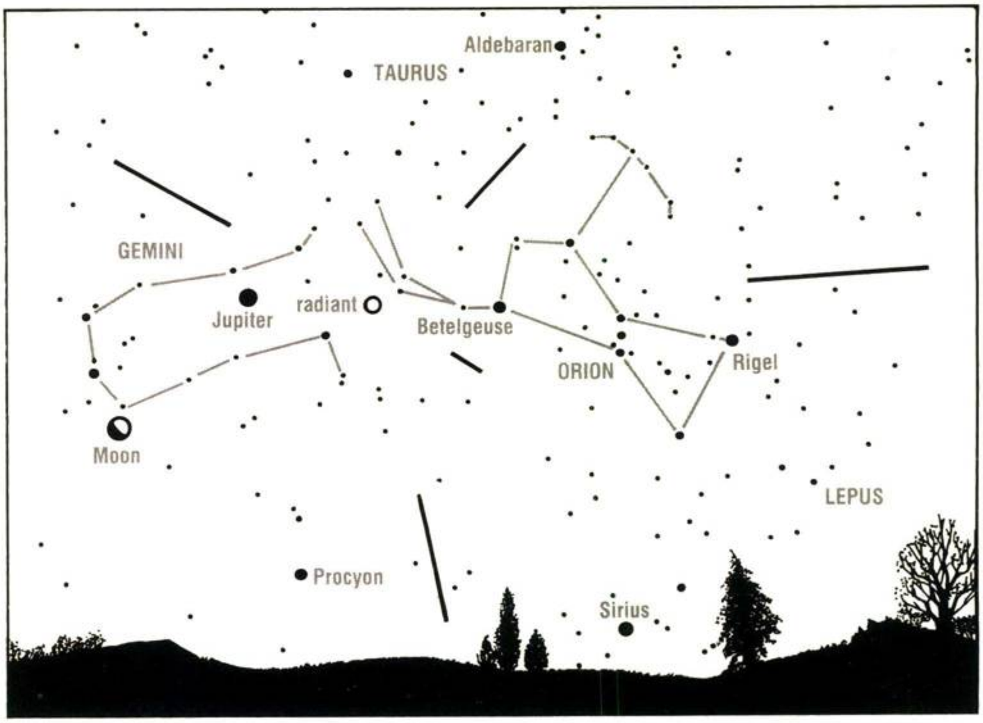
LOOK FOR MERCURY this month as it puts on its best morning appearance of 1989. At its highest, the innermost planet appears 8° above the eastern horizon 45 minutes before sunrise.



A MOON FOR HUNTERS AND TIDE WATCHERS

Full Moon this month comes on October 14. This is the Hunter's Moon, the first Full Moon following last month's Harvest Moon. The Harvest Moon rises just thirty minutes later each successive evening, the shortest delay between moonrises all year, and the Hunter's Moon is not far behind. While the light from the Full Harvest Moon helps farmers bring in their crops, the Hunter's Moon the following month illuminates the cut fields, which allows hunters to spot their prey more easily.

Just five hours after the Moon is Full, the Moon reaches perigee, its closest approach to Earth in its monthly orbit. This particular perigee brings the Moon closer to



OCTOBER'S BEST METEOR SHOWER, the Orionids, peaks on the morning of October 21, when ten to fifteen meteors an hour should radiate from the vicinity of Orion's club.

Earth than at any other time this year. Thus conditions are ripe for particularly high tides, known as "spring tides." Although spring tides in the autumn may sound impossible, the word "spring" stems from the Middle English verb *springen,* meaning "to leap up." It has nothing whatsoever to do with the seasons.

Tides are influenced by the gravitational pull of both the Moon and the Sun, and the Moon's contribution is about twice that of the Sun. Tides are normally highest around New and Full Moon when the Sun, Moon, and Earth are in a line. Because this month's Full Moon occurs so near to the year's closest perigee, the Moon's pull is greater than usual and tides will run abnormally high. Although you probably won't need to head for higher ground (unless a strong storm exacerbates the high tides), the tides on October 14 offer a vivid example of how astronomical forces effect the world around us.

TWO CHALLENGING METEOR SHOWERS

Two well-known meteor showers peak this month, but conditions are not favorable for either of them. The Draconids peak on October 8, when the Moon is absent from the morning sky. This shower is particularly good in years when its parent comet, Giacobini-Zinner, is nearby, because most of the meteors swarm close behind the comet. Unfortunately, Giacobini-Zinner last passed Earth in 1985 and won't return until 1992, so this year's shower won't produce many meteors.

The Orionid meteor shower peaks on the morning of October 21. This is often a good shower, producing twenty-five to thirty meteors per hour, but this year the Last Quarter Moon interferes. Most of the faint Orionids will be lost in the glare of the half-lit Moon during the after-midnight hours when the shower is usually at its best.

OCTOBER'S PLANETS

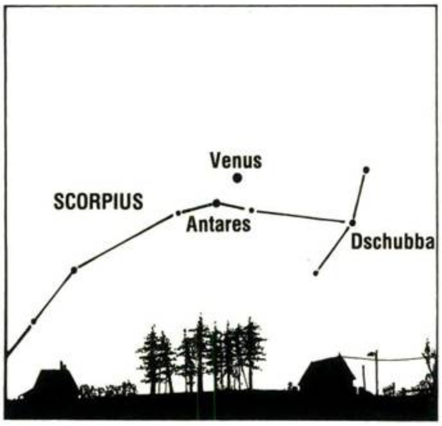
Venus lies in the southwest after sunset, shining brilliantly at magnitude −4.2. Venus is by far the brightest planet; and even though it will remain fairly low in the twilight sky throughout this fall and early winter, it is still a sight to behold. Look for Venus especially on the evening of October 3, when it lies about 3° north of the slim crescent Moon.

Venus begins October in Libra but quickly moves into the head of neighboring Scorpius. Three stars in a little arc represent the scorpion's head and are sometimes called the "crown of the scorpion." Venus passes only 0.5° from the middle star in the head, Dschubba, on the evening of October 10. Six days later, Venus sweeps less than 2° from the brightest star in Scorpius, orange-red Antares.

Venus' rapid eastward motion soon brings it closer to another prominent planet, Saturn. Low in the south at sunset, Saturn shines at magnitude 0.5 against the rich background of the constellation Sagittarius.

If you've watched Saturn throughout the year, you know it has remained low in the southern sky. On October 2 the ringed planet lies farther south on the starry dome than at any time since 1959. On October 2 Saturn begins a long, slow climb northward that will continue into

BRILLIANT VENUS passes within 2° of Scorpius' brightest star, Antares, on October 16. Look for the pair low in the southwest about 45 minutes after sunset.



the early twenty-first century. Saturn will then appear high in the sky to Northern Hemisphere observers.

Now dominating the morning sky, Jupiter continues to get brighter and rise earlier on the way to its December opposition. The giant planet now rises before midnight and appears high in the south before dawn. It shines boldly at magnitude −2.4 among the stars of Gemini.

Innermost Mercury has its best morning apparition of the year in October, with greatest elongation occurring on October 10. Mercury is easiest to see around the 10th, but you might want to try following it as it sinks closer to the horizon later in the month. On October 25 Mercury passes 4° north of Spica, the brightest star in the constellation Virgo. Spica is probably too near the horizon to be visible without binoculars at this time, but magnitude −1.0 Mercury should be bright enough to see with the naked eye.

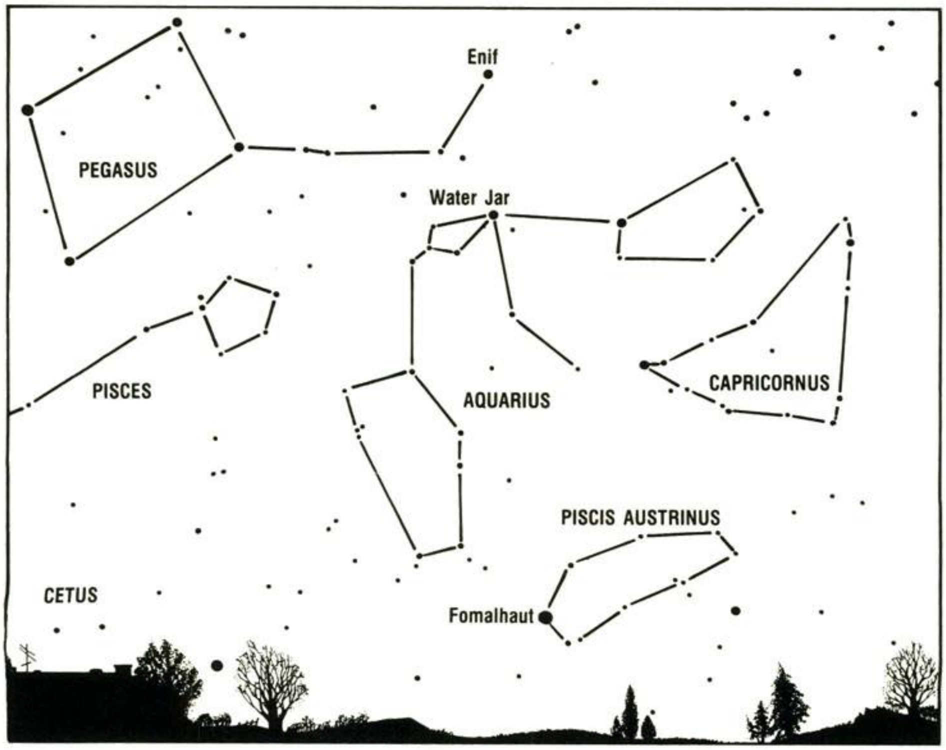
Mars is still located on the far side of the Sun and is lost from view this month. The Red Planet will return to the predawn sky in the second half of November.

OCTOBER'S STARRY SKY

The zodiacal constellation Aquarius now arcs across the southern sky each evening. It is a large, dim constellation with no planets near it at this time. However, the waxing gibbous Moon can guide you to this group of stars as it sweeps through the region from around October 10 to 12.

Aquarius contains a famous asterism (grouping of stars) within its boundaries. This is the faint but distinctive pattern known as the Water Jar. A line between Enif, the nose of the Flying Horse (Pegasus), and Fomalhaut, the brightest star in the constellation of the Southern Fish (Piscis Austrinus), runs approximately through the Water Jar. The asterism is about one-third of the way from Enif to Fomalhaut.

The constellation Aquarius has been known since ancient times as a Water Carrier. Many old star atlases show water pouring from the Water Jar into the open mouth of the Southern Fish. Under a very dark sky it's possible to see a zigzag line of stars leading from the Water Jar to Piscis Austrinus like a trickle of water.



AQUARIUS THE WATER CARRIER forms a distinctive pattern in the southern sky on October evenings. Although Aquarius has no stars brighter than 3rd magnitude, it is easy to locate between Enif and 1st-magnitude Fomalhaut.

The two brightest stars in Aquarius are Sadalmelik and Sadalsuud; both shine at magnitude 2.9. These stars were once considered to bring good fortune. Sadalmelik means "the lucky one of the king," and Sadalsuud means "the luckiest of the lucky."

The names stem from the long association of the stars of Aquarius with the rainy season for many ancient cultures. Indeed, many of the constellations in this region of the heavens are associated with water because of the Sun's position during the rainy months.

As a constellation of the benevolent season of the rains, Aquarius was also associated in ancient Greece with Zeus, the king of the gods and giver or taker or life. In Egyptian mythology the Water Carrier was depicted pouring water into the River Nile during the time of year when the Nile overflowed its banks and irrigated the surrounding farmlands.

JUPITER'S CHANGING RHYTHMS

JUPITER'S GREAT RED SPOT is less prominent now than it was in 1978, when Thomas Rotkiewicz photographed it. Your best chance to see the spot is when it transits Jupiter's disk.

Jupiter opens the month of October in the constellation Gemini and sports a disk 39″ in equatorial diameter and 36″ in polar diameter. By the end of the month, Jupiter appears significantly larger in the eyepiece: 43″ across its equator and 40″ across its poles. Jupiter's magnitude also brightens over the same period from −2.3 to −2.5. But for several reasons, the most interesting milestone for backyard observers this month occurs on October 1, when Jupiter is at quadrature. On that date the giant planet lies exactly 90° west of the Sun along the ecliptic.

You can see Jupiter's phase more easily at quadrature than at any other position in its orbit. When you view Jupiter this month, the western limb of the planet appears less defined than the eastern limb. This is because the Jovian terminator lies on clouds of ammonia ice crystals at the top of Jupiter's atmosphere. The clouds diffuse sunlight falling on them, so the terminator appears less sharp than the Martian and lunar terminators, which lie on solid surfaces.

During quadrature Jupiter's shadow falls at its westernmost position with respect to the Jovian sphere. Thus, we view eclipses of Jupiter's moons when they are farther from Jupiter's disk than usual; therefore, the planet does not block our view of the events. For instance, phenomena we normally see only with Ganymede can also be seen with Europa.

One of these events occurs on the morning of October 1. As Europa passes behind Jupiter's disk from west to east, it is first eclipsed by Jupiter's shadow at 7:28 universal time (3:28 a.m. EDT; 12:28 a.m. PDT), then reemerges from the shadow at 10:01 universal time (6:01 a.m. EDT; 3:01 a.m. PDT), only to be occulted by the planet's disk three minutes later at 10:04 universal time (6:04 a.m. EDT; 3:04 a.m. PDT). Finally, it reemerges from occultation at 12:41 universal time (8:41 a.m. EDT; 5:41 a.m. PDT). Although observers on the East Coast miss the end of the occultation, the rest of the country can see the entire event.

Even distant Callisto gets into the act this month, although quadrature has nothing to do with it. The outermost Galilean satellite is not occulted, does not transit, or undergo any eclipse phenomena when the plane of the Galilean satellites' orbits is tilted more than about 2.5° to the ecliptic. This was the case for most of 1987, all of 1988, and the first nine months of 1989, but it changes in October. On October 7/8, Jupiter occults Callisto for just under an hour, beginning at 2:49 universal time (10:49 p.m. EDT on October 7) and ending at 3:36 universal time (11:36 p.m. EDT). Unfortunately, this event is visible only from the East Coast of North America, and Jupiter is very low in the sky during the event. West Coast observers can view Callisto's transit of the Jovian disk on October 16 between 13:09 universal time (6:09 a.m. PDT) and 14:11 universal time (7:11 a.m. PDT). The table at right lists other phenomena for the Galilean satellites this month.

One final Jovian feature deserves your attention: the Great Red Spot. Earlier this year I exhorted you to observe the Red Spot because several observers (myself included) believed it might be reddening. It appears we were wrong. In fact, many observers were unable to detect the spot at all in the months before Jupiter reached conjunction on June 9.

If you want to try observing the Red Spot (or is it now the Blank Spot?), consult the table for the times when it should be visible from North America. Remember that these times are only approximate because the Spot hasn't been observed for some time. You should begin observing at least twenty minutes before the predicted time.

TRANSIT TIMES OF JUPITER'S GREAT RED SPOT

Date	Time
October 1	3:58 a.m. EDT
October 3	5:37 a.m. EDT
October 4	1:58 a.m. EDT
October 6	3:07 a.m. EDT
October 8	4:45 a.m. EDT
October 10	6:23 a.m. EDT
October 11	2:15 a.m. EDT
October 13	3:53 a.m. EDT
October 15	5:31 a.m. EDT
October 16	1:22 a.m. EDT
October 18	3:01 a.m. EDT
October 20	4:39 a.m. EDT
October 22	6:17 a.m. EDT
October 23	2:09 a.m. EDT
October 25	3:47 a.m. EDT
October 27	5:25 a.m. EDT
October 28	1:16 a.m. EDT
October 30	1:54 a.m. EST

GALILEAN SATELLITE PHENOMENA

Date	Event	Time
	IO	
Oct. 18	Eclipse Begins	6:15
	Occultation Ends	9:47
Oct. 26	Shadow Enters	5:25
	Transit Begins	6:37
	Shadow Leaves	7:37
	Transit Ends	8:49
	EUROPA	
Oct. 10	Shadow Enters	4:30
	Shadow Leaves	7:05
	Transit Begins	7:08
	Transit Ends	9:47
	GANYMEDE	
Oct. 26	Shadow Enters	2:34
	Shadow Leaves	5:24
	Transit Begins	7:26
	Transit Ends	10:21
	CALLISTO	
Oct. 8	Occultation Begins	2:49
	Occultation Ends	3:36

Times are given in universal time. Subtract 4 hours to obtain EDT, 5 hours for CDT, 6 hours for MDT, and 7 hours for PDT.

MERCURY'S MORNING MEANDERINGS

The planet closest to the Sun makes a very good morning appearance in October, reaching a greatest elongation of 18° west of the Sun on the 10th. During the first three weeks of the month, telescopic observers can watch as Mercury's phase waxes from a nearly New Moon appearance on the 1st, to half-lit on the 10th, to a fat gibbous on the 21st. The planet is hardest to see on the 1st, when it rises less than an hour before the Sun and shines at magnitude 2.1. Look for it about thirty minutes before sunrise, when it lies a few degrees south of east and 5° above the horizon. By October 21 Mercury has brightened by over three magnitudes to magnitude −1.0, so it is much easier to find. You can follow Mercury for another week past that date, but its phase changes little. Mercury's waxing phase is paralleled by the planet's shrinking size. On October 1, Mercury's disk appears 9″ across, and by the 27th it has diminished to 5″ in apparent diameter.

You're unlikely to see anything but a featureless crescent when observing Mercury early in October. However, as the "half-Moon" phase approaches, you may notice a subtle, uneven shading on the sunlit surface of the planet near the terminator. This is caused by sunlight striking the rough surface of Mercury at a grazing angle, which scatters the sunlight and keeps it from reaching our eyes.

BLOCKING STARLIGHT FROM THE BEEHIVE

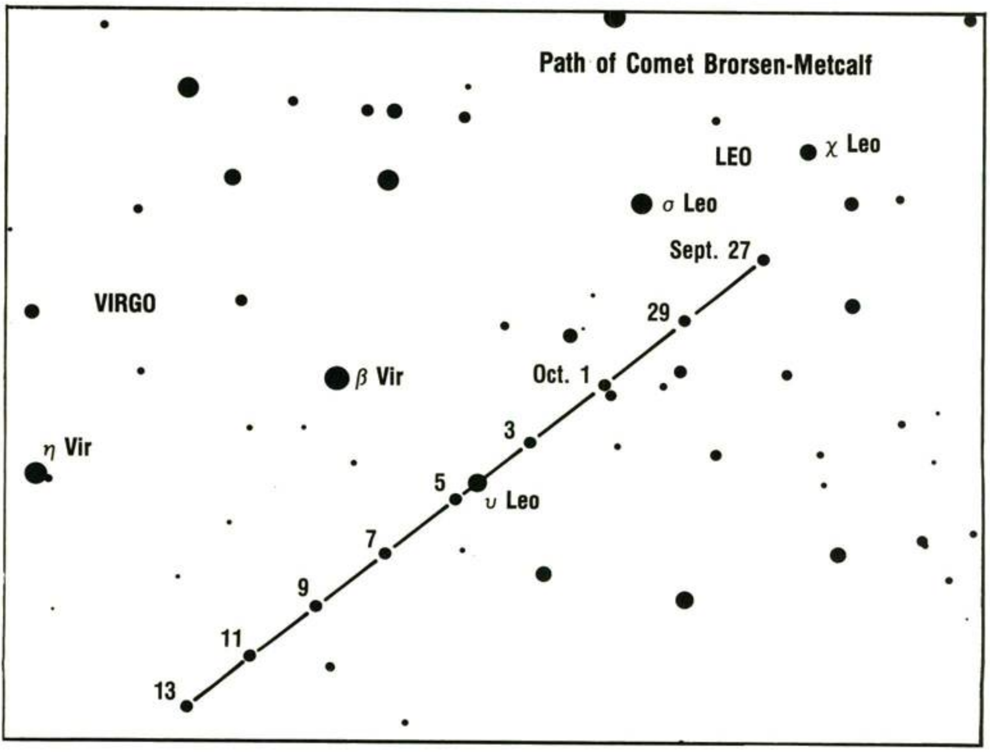
The Moon passes in front of the Beehive Cluster (M44) on the night of October 21/22 for observers in eastern North America. The middle of the occultation occurs around 1 a.m. EDT on the 22nd, but the Beehive is so large — it spans approximately 1.5° — that the Moon takes two to three hours to pass the whole cluster. Observers in western North America won't see any stars occulted, but they will see the Moon pass very near the famous open cluster.

The crescent Moon is 43-percent lit at the time of the occultation. Therefore, lunar glare won't overwhelm the stars' light, and you'll be able to see many of the fainter cluster members as they are occulted. Because the lunar phase is waning, the stars disappear behind the lit portion of the Moon and reappear from behind the Moon's dark limb.

COORDINATES FOR COMET BRORSEN-METCALF

Date	R.A. (2000)	Dec.
Sept. 27	11h09.2m	4°47′
Sept. 29	11h17.1m	3°12′
Oct. 1	11h24.6m	1°41′
Oct. 3	11h31.9m	0°13′
Oct. 5	11h39.0m	−1°11′
Oct. 7	11h45.9m	−2°32′
Oct. 9	11h52.5m	−3°49′
Oct. 11	11h58.9m	−5°03′
Oct. 13	12h05.1m	−6°14′

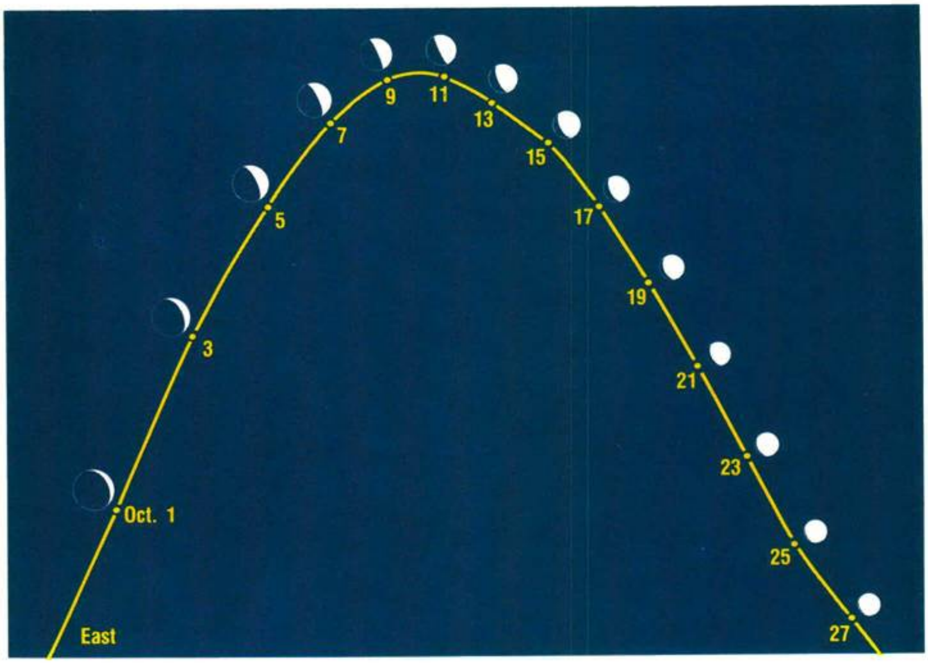
THE BEST COMET of 1989, Comet Brorsen-Metcalf moves from Leo into Virgo in early October. The fading comet should be visible in binoculars or a telescope low in the east before sunrise.



COMET BRORSEN-METCALF ON THE WANE

Comet Brorsen-Metcalf should be a binocular object in late September and early October. Astronomers expect the comet to shine at 7th magnitude during the Moon-free observing period that lasts until about October 13. However, Brorsen-Metcalf moves from southern Leo into Virgo during this period thus is close to the eastern horizon as morning twilight begins. By late October, when the Moon is again out of the way, the comet is lost in the glare of the Sun.

Astronomer Eleanor Helin recovered Comet Brorsen-Metcalf on July 5/6 using the 18-inch Schmidt camera at Palomar Observatory. It was in central Pisces at the time, nearly an hour of right ascension east and 10° of declination north of its predicted position. This certainly helps explain why astronomers failed to recover the comet earlier! On July 6/7 Charles Morris and I observed Brorsen-Metcalf visually from Lockwood Valley, California, with a 20-inch Newtonian telescope. The comet shone at magnitude 10.4 and had a diffuse coma 5′ across. Alan Hale observed the comet that night from New Mexico and saw the same 5′ coma but assigned a magnitude of 11.4 to it. So even though Brorsen-Metcalf reached perihelion sixteen days sooner than predicted, its magnitude seems close to the predicted values.



MERCURY'S PHASE AND SIZE change rapidly during October, forming a fascinating progression to watch through your telescope's eyepiece.

TELESCOPIC PLANETS

Venus continues to flirt with the western horizon in the evening sky this month. At the beginning of October it lies approximately 10° above the southwestern horizon 45 minutes after sunset. By month's end it has gained over 3° in altitude and its phase has shrunk from distinctly gibbous to just over half-lit. Despite the shrinking phase, Venus brightens from magnitude −4.1 to −4.3 in October because the phase is more than offset by the rapidly increasing size of Venus' disk, which grows 30 percent this month from 17″ in diameter to 23″ across.

Mars was in conjunction with the Sun on September 29 and remains too near the Sun to be viewed during October. The Red Planet won't be easy to view again until the middle of November.

Saturn is well placed for observing in the early evening hours this month, but there is little change in the ringed planet's telescopic appearance. The planet's magnitude stays constant at 0.5, its equatorial diameter shrinks from 16.6″ to 15.8″, the diameter of the rings drops from 37.6″ to 35.9″, and the tilt of the rings remains unchanged at 26°.

Saturn is at quadrature on October 6; however, Saturn's quadrature is less eventful than Jupiter's because Saturn is almost twice as distant as Jupiter. Quadrature does have one noticeable effect on the appearance of Saturn. The shadow cast onto the rings by the ball of the planet appears largest at this time, though the shadow is also evident throughout September, October, and much of November.

Uranus and Neptune remain in the same part of the sky as Saturn, so they appear best in the early evening. Unfortunately, Uranus and Neptune are very remote and show few if any details, even in the largest amateur telescopes under the best conditions. Uranus sports a 3.6″-diameter blue-green disk and shines at magnitude 5.7 this month. Neptune's 2.2″-diameter disk appears bluish gray in the eyepiece and shines faintly at magnitude 7.9.

ASTEROIDS IN THE EYEPIECE

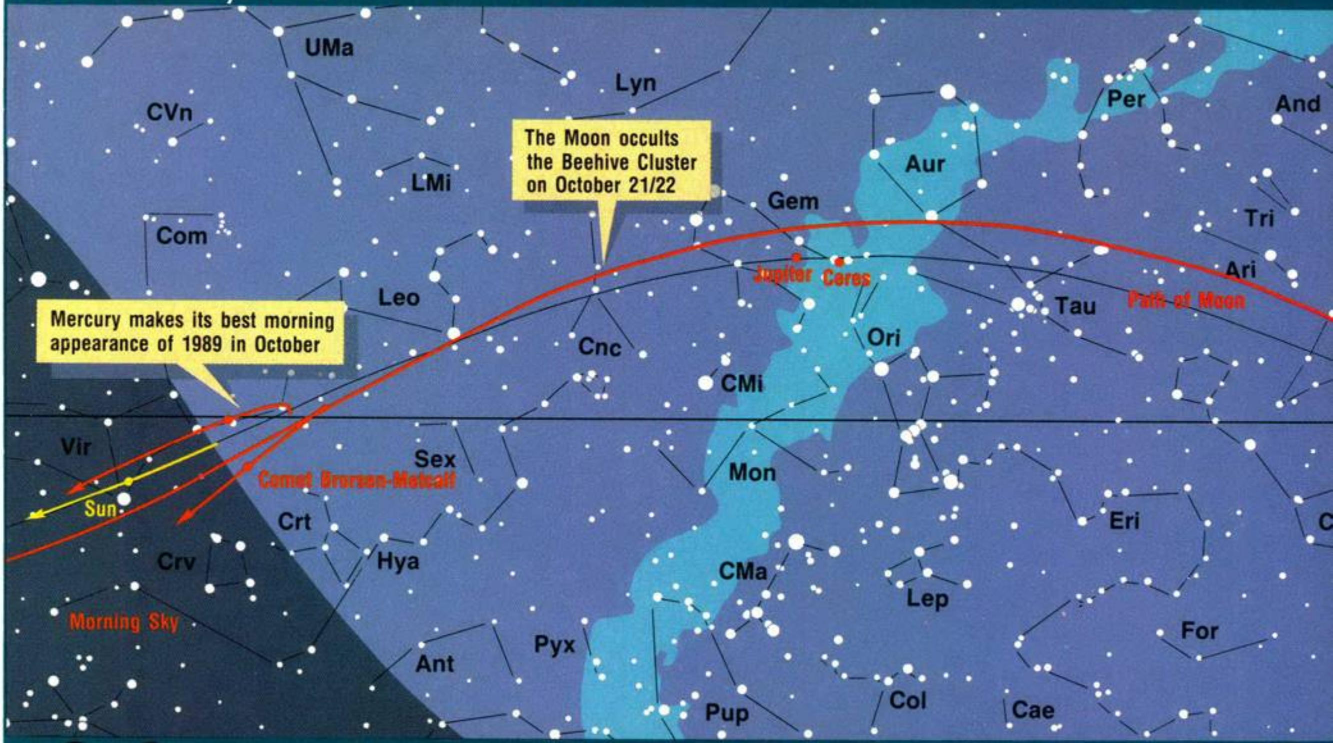
Asteroid 2 Pallas reached opposition on the last day of September, so it remains bright and easy to view. Use the table of coordinates at right to find the 8th-magnitude minor planet this month as it traverses Cetus. Asteroid 4 Vesta steals the show from Pallas, however, when it passes only 37′ north of the magnitude 2.1 star Sigma (σ) Sagittarii (Nunki) on October 13. In the morning sky 8th-magnitude 1 Ceres passes 9′ south of the 3.2-magnitude star Mu (μ) Geminorum on October 28. Both Vesta and Ceres offer you a good chance this month to observe the motion of an asteroid over a short period of time. ☐

COORDINATES FOR PALLAS

Date	R.A. (2000)	Dec.
Oct. 1	0h50.6m	−10°40′
Oct. 6	0h46.7m	−11°57′
Oct. 11	0h42.8m	−13°09′
Oct. 16	0h39.1m	−14°17′
Oct. 21	0h35.5m	−15°18′
Oct. 26	0h32.1m	−16°12′
Oct. 31	0h29.2m	−16°59′
Nov. 5	0h26.8m	−17°39′
Nov. 10	0h24.8m	−18°10′
Nov. 15	0h23.5m	−18°35′
Nov. 20	0h22.7m	−18°52′
Nov. 25	0h22.5m	−19°03′
Nov. 30	0h23.0m	−19°08′

Positions for asteroid 2 Pallas are given for 0 UT.

The Solar System October 1989


UMa
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CVn
LMi
Com
Leo
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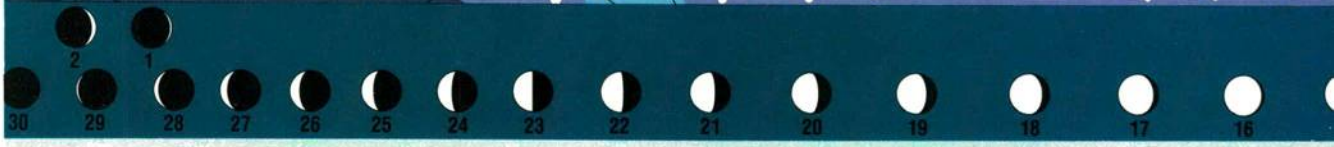
Gem
Aur
Per
And
Tri
Ari
Tau
Ori
CMi
Mon
Vir
Sex
Crt
Crv
Hya
Sun
Jupiter
Ceres
Comet Brorsen-Metcalf
Path of Moon
CMa
Lep
Eri
For
Ant
Pyx
Pup
Col
Cae
Morning Sky

The Moon occults the Beehive Cluster on October 21/22

Mercury makes its best morning appearance of 1989 in October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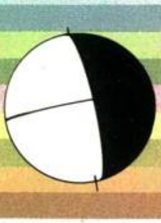
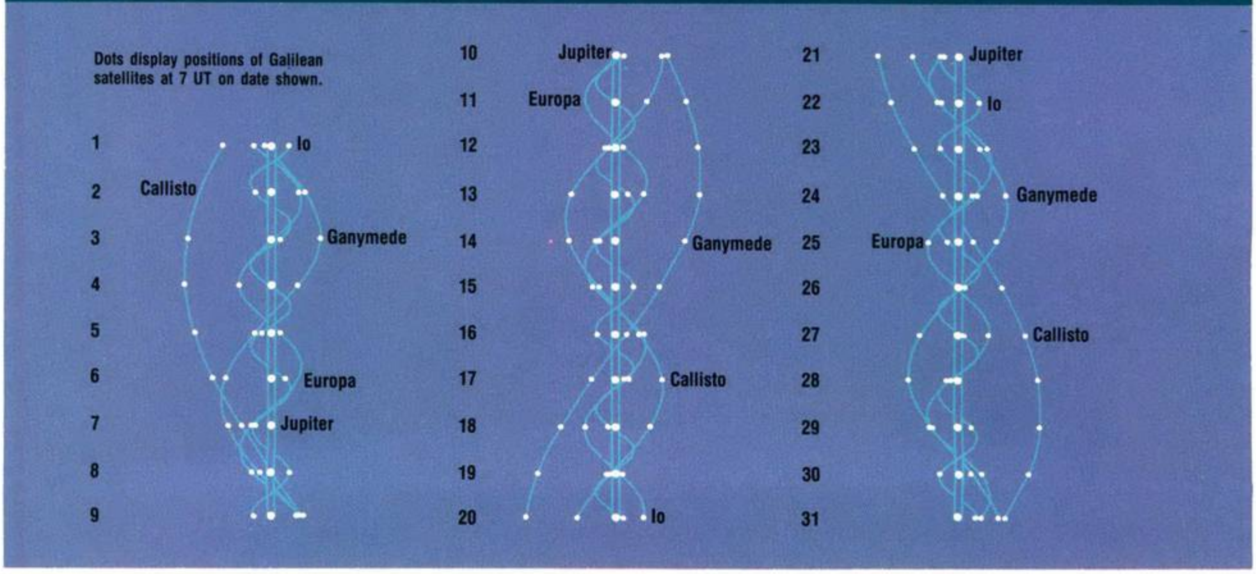
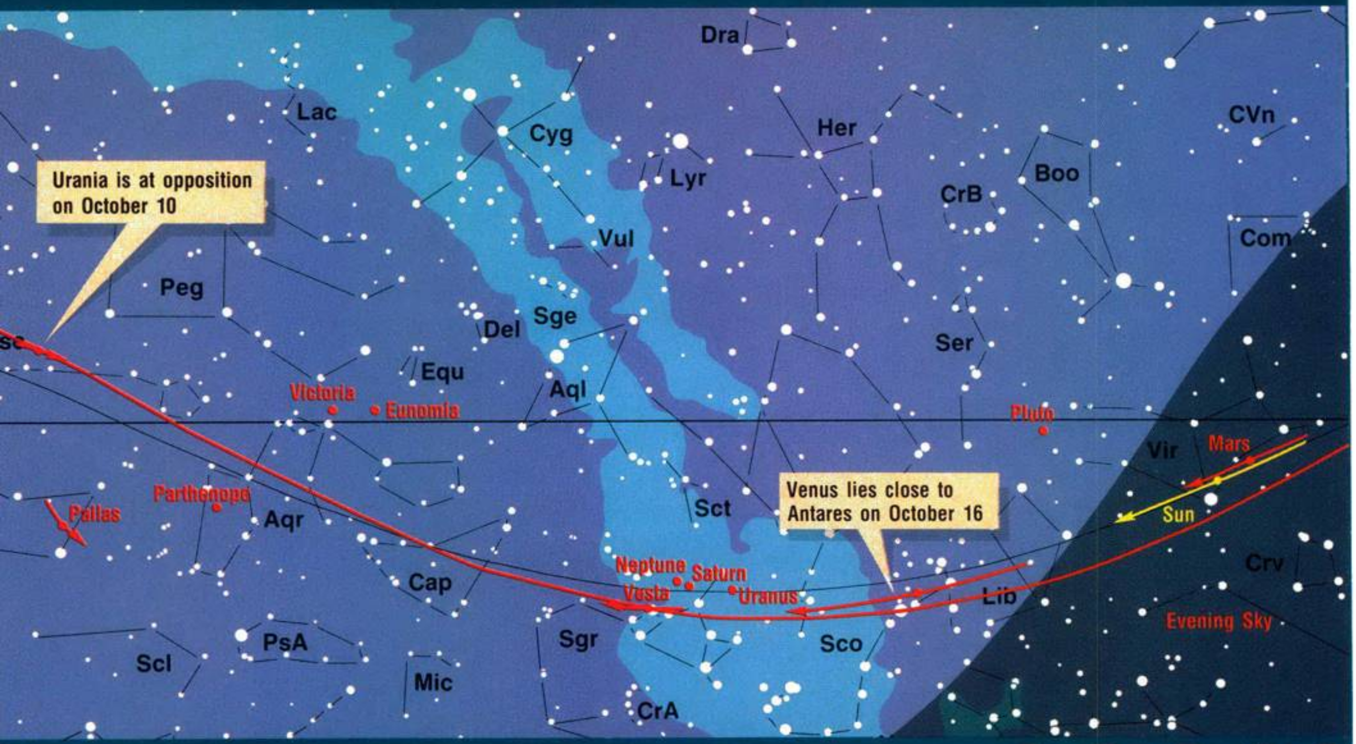


Planet	MERCURY	MERCURY	MERCURY	VENUS	MARS
Date	October 1	October 15	October 31	October 15	October 15
Magnitude	+2.1	−0.8	−1.1	−4.2	+1.7
Angular Size	9.27″	6.17″	4.89″	19.5″	3.6″
Illumination	10%	71%	98%	61%	100%
Distance (AU) from Earth	0.726	1.090	1.375	0.854	2.622
Distance (AU) from Sun	0.323	0.322	0.408	0.728	1.631
Right Ascension (2000.0)	11h46.5m	12h21.0m	13h56.6m	16h19.6m	13h02.6m
Declination (2000.0)	0°37′	−0°08′	−10°40′	−24°10′	−5°57′

Jupiter's Moons



Dots display positions of Galilean satellites at 7 UT on date shown.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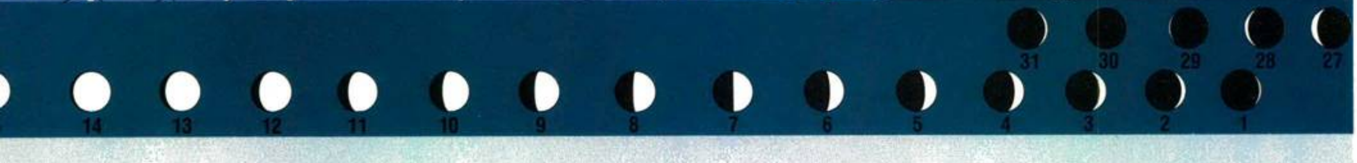
Lyr
Boo
CrB
Com
Peg
Vul
Del
Sge
Ser
Equ
Aql
Victoria
Eunomia
Pluto
Vir
Mars
Parthenope
Pallas
Aqr
Sct
Sun
Crv
Cap
Neptune
Saturn
Vesta
Uranus
Lib
Evening Sky
PsA
Sgr
Sco
Scl
Mic
CrA

Urania is at opposition on October 10

Venus lies close to Antares on October 16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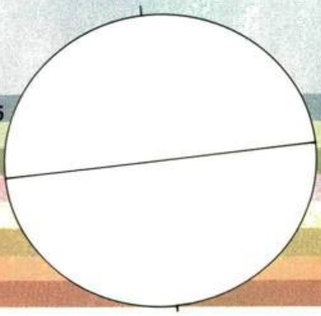
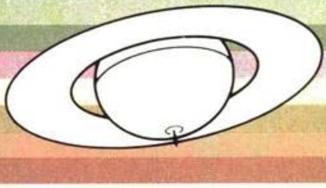
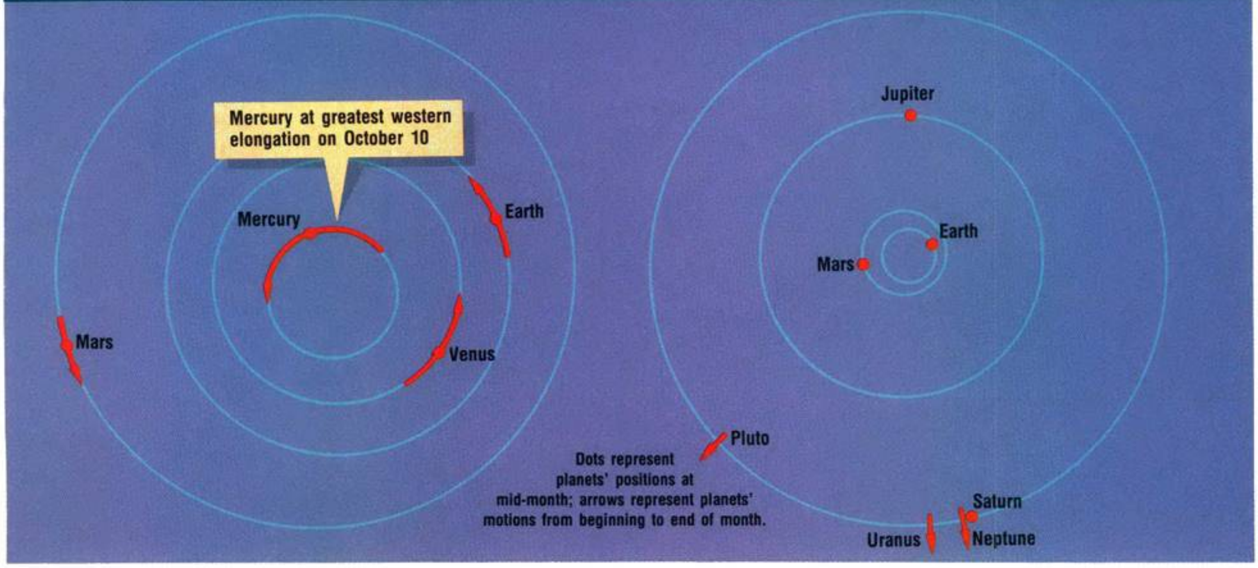




JUPITER	SATURN	URANUS	NEPTUNE	PLUTO
October 15	October 15	October 15	October 15	October 15
−2.4	+0.5	+5.7	+7.9	+13.8
40.7″	16.2″	3.6″	2.2″	0.1″
99%	100%	100%	100%	100%
4.837	10.216	19.681	30.401	30.541
5.123	10.032	19.366	30.212	29.656
6h46.4m	18h36.3m	18h08.7m	18h42.8m	15h05.3m
22°45′	−22°46′	−23°42′	−22°11′	−1°36′

The Planets in Their Orbits


Mercury
Earth
Mars
Venus
Jupiter
Earth
Mars
Pluto
Saturn
Uranus
Neptune

Mercury at greatest western elongation on October 10

Dots represent planets' positions at mid-month; arrows represent planets' motions from beginning to end of month.

ASTRONOMY'S 1989 GUIDE TO TELESCOPES

"Know yourself" is the first rule of telescope buying: how much do you want to spend, what do you want to observe, and how mobile are you.

by the Editors of ASTRONOMY

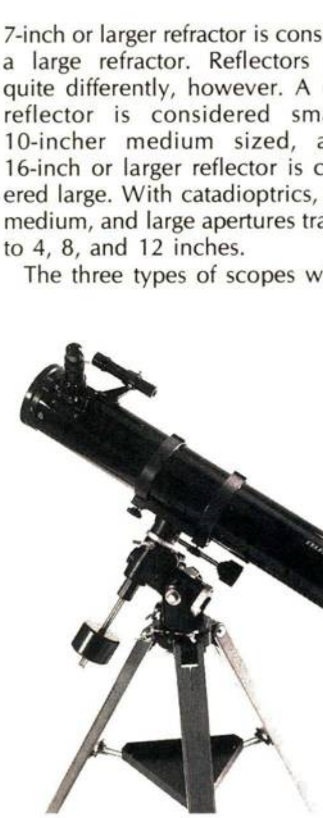
Finding the telescope that's right for you is the most important step you can take in amateur astronomy. The scope you buy will either expand your enjoyment of astronomy by providing many hours of observing fun or end up sitting in the attic, unused and unappreciated. Today's marketplace is crowded and bewildering, filled with numerous models with similar claims and promises. Yet there *are* ways to find your ideal telescope.

As a first step, learn about the three basic types of telescopes. Refractors have an objective lens at one end and the eyepiece at the other. They provide superior image quality, especially apochromatic refractors (those with triplet lenses). Reflectors, telescopes that use mirrors to form an image, provide the most aperture on a dollar-for-dollar basis. Catadioptric telescopes use a combination of lenses and mirrors and deliver an extremely compact instrument that is conveniently equipped for astrophotography.

The type and size of the telescope that's best for you depends on what kind of observing you want to do with it. Maybe you want to see all of the galaxies in the *Revised New General Catalogue* and you've developed a desire for a big "light bucket" reflector, perhaps on a Dobsonian mount. Or maybe you're passionate about the planets and you want an apochromatic refractor. Or maybe you've developed an interest in photographing the sky and you want to collect your own set of pictures of the Messier objects. In that case, a Schmidt-Cassegrain reflector with photographic accessories might be the way to go.

Setting Your Sights

Like just about everything else, telescopes come in three sizes: small, medium, and large. Small refractors are generally considered those with 3 inches or less of aperture. A 5-inch refractor is medium sized, and a 7-inch or larger refractor is considered a large refractor. Reflectors group quite differently, however. A 6-inch reflector is considered small, a 10-incher medium sized, and a 16-inch or larger reflector is considered large. With catadioptrics, small, medium, and large apertures translate to 4, 8, and 12 inches.



Celestron's C4.5
4.5-inch f/7.9 Newtonian

The three types of scopes will not perform identically. A well-made 6-inch Newtonian reflector shows fainter stars and provides better resolution than the 3-inch refractor or a 4-inch catadioptric. But, on the other hand, the 3-inch refractor might give crisper images than the 4-inch catadioptric or the 6-inch reflector. Overall, medium-sized telescopes of each type are about equally useful for an average observer.

Finding the Proper Mounting

Choosing a telescope with an adequate mounting is important for your future enjoyment of astronomy. Carefully consider the three types of mountings: equatorial, altazimuth, and Dobsonian. Each of these mountings is sufficient for a foray into backyard stargazing, *if the mount is solid and stable*. A stable mount lets you enjoy stargazing; a wobbly mount will give you only misery as you watch images jiggle in the eyepiece.

Altazimuth mountings are attractively inexpensive. Unfortunately, however, they are inconvenient and occasionally outright clumsy to use. Consisting of motions in altitude (up and down) and azimuth (left to right), these mountings make following a celestial object tricky. You need to keep twiddling the knobs that move the telescope — first a little up, then a little right, then a little up, and so on. Equatorial mountings eliminate this problem because one axis of rotation points to the pole, and you can follow a star or planet in a single, smooth motion. An equatorial mounting can be a joy to use.

Dobsonian mountings are technically altazimuth mounts but are much easier to use because you simply push on the scope to move it. Big Newtonian "light bucket" reflectors typically have Dobsonian mounts because they are simple and cheap, making telescopes with extremely large mirrors available at small prices. For deep-sky observers interested in the biggest aperture for the smallest number of dollars, we recommend Dobsonian mounts.

How Large Should You Go?

Big mirrors or lenses collect more light than small ones. Therefore, the larger your telescope's aperture, the brighter the views. Does this mean bigger is better? Up to a point it does. A big *aperture* is a blessing; a big *telescope* is a mixed blessing. Ask yourself if you really want a 350-pound monster that gives great views of galaxies but stands eight feet tall and requires a small truck for transport. Remember, you want a telescope that you can use *often*. A telescope that sits

REFRACTORS

Manufacturer and model	Aperture (inches)	Focal ratio	Type of optics	Mounting type	Clock drive	Slow motion	Setting circles	Drive corrector	Eyepieces	Finder scope	Focuser size	Total weight	Limiting magnitude / Resolution	Magnification / Field of view	Manufacturer's retail list price	Features
ASTRO-PHYSICS																
4″ f/8 Starfire	4	8	APO	—	—	—	—	—	—	—	2	9	12.0/1.1	32/1.9	$1,345	AM
5″ f/8 Starfire	5	8	APO	—	—	—	—	—	—	—	2	14	12.7/0.9	40/1.5	$1,850	AM
Super Planetary	6	12	APO	—	—	—	—	—	—	—	2	21	13.4/0.8	72/0.8	$2,050	AM
6″ f/9 Starfire	6	9	APO	—	—	—	—	—	—	—	2	20	13.4/0.8	54/1.1	$2,680	AM
7″ f/9 Starfire	7	9	APO	—	—	—	—	—	—	—	2/2.7	29	13.7/0.7	63/1	$3,975	AM
CELESTRON INTERNATIONAL																
C60	2.4	13.3	ACH	AA	—	✓	—	—	1	5x20	0.96	8	10.5/1.9	32/1.2	$218	AMT
C60E	2.4	13.3	ACH	GE	W	✓	✓	—	1	5x20	0.96	12	10.5/1.93	32/1.2	$458	AMT
Firstscope 80	3.1	11.4	ACH	AA	—	✓	—	—	1	6x30	1.25	18	11.0/1.5	36/1.7	$850	AEMT
SP-C102	4	9.8	ACH	GE	W	✓	✓	—	1	6x30	1.25	37	12.0/1.1	39/1.5	$1,900	AEMPT
SP-C102F	4	8.8	FL	GE	W	✓	✓	—	1	6x30	1.25	36	12.0/1.1	36/1.7	$3,900	AEMPT
CHESHIRE																
5″ f/5	5	5	ACH	GE	✓	—	—	—	1	—	2	34	12.7/0.9	25/2.4	$2,789	MT
5″ f/15	5	15	ACH	GE	✓	✓	✓	✓	1	—	2	67	12.7/0.9	76/0.8	$4,985	MT
6″ f/8	6	8	ACH	GE	✓	✓	✓	✓	1	—	2	66	13.4/0.8	49/1.2	$5,485	MT
6″ f/15	6	15	ACH	GE	✓	✓	✓	✓	1	—	2	87	13.4/0.8	91/0.7	$6,185	MT
8″ f/15	8	15	ACH	GE	✓	—	✓	✓	1	—	2	110	13.9/0.6	122/0.5	$13,885	MH
10″ f/5	10	5	ACH	—	—	—	—	—	1	—	2	n/a	14.2/0.5	50/1.2	$8,195	M
12″ f/15	12	15	ACH	—	—	—	—	—	1	—	2	n/a	14.5/0.4	183/0.3	$11,000	M
DOBBINS INSTRUMENT COMPANY																
4.5″ f/12.5	4.5	12.5	ACH	GE	W	✓	✓	✓	—	8x50	2	52	12.3/1.0	57/1.0	$3,470	TP
5″ f/15	5	15	ACH	GE	W	✓	✓	✓	—	8x50	2	63	12.7/0.9	76/0.8	$3,640	TP
6″ f/10	6	10	ACH	GE	W	✓	✓	✓	—	8x50	2	70	13.4/0.8	60/1	$4,270	TP
6″ f/15	6	15	ACH	GE	W	✓	✓	✓	—	8x50	2	115	13.4/0.8	90/0.7	$8,790	HP
8″ f/15	8	15	ACH	GE	W	✓	✓	✓	—	12x80	2	520	13.9/0.6	51/1.2	$14,485	HP
10″ f/10	10	10	ACH	GE	W	✓	✓	✓	—	12x80	2	560	14.2/0.5	100/0.6	$16,885	HP
EDMUND SCIENTIFIC																
31,611	2.4	8	ACH	EF	—	—	—	—	1	5x24	1.25	7	10.5/1.9	19/3.1	$369	AMT
JASON EMPIRE																
313	2.4	15	ACH	GE	—	✓	✓	—	3	10x	.965	26	10.5/1.9	36/1.7	$480	AGHMRT
324	3.1	15	ACH	GE	—	✓	—	—	4	6x30	.965	43	11.0/1.5	48/1.3	$980	AGHMRT
MEADE INSTRUMENTS CORPORATION																
226	2.4	12	ACH	AA	—	—	—	—	2	5x24	.965	12	10.5/1.9	28/2.1	$250	AMT
291	2.4	15	ACH	GE	—	✓	✓	—	2	6x30	.965	19	10.5/1.9	36/1.7	$500	AMT
312	3.1	11	ACH	AA	—	✓	—	—	1	5x24	1.25	22	10.5/1.9	36/1.7	$850	AMT
323	3.1	11	ACH	GE	—	✓	✓	—	1	5x24	1.25	36	11.0/1.5	35/1.7	$1,100	AMT

Type of optics: ACH (achromat), APO (apochromat), 2APO (two-element apochromat), CAS (Cassegrain), FL (calcium fluoride), HA (hyperbolic astrograph), MAK (Maksutov-Cassegrain), NEWT (Newtonian), SCT (Schmidt-Cassegrain), SN (Schmidt-Newtonian).
Mounting type: AA (altazimuth), DOB (Dobsonian), EF (equatorial fork), GE (German equatorial).
Clock drive: W (worm-gear drive), S (spur-gear drive).
Finder scope included: Magnification and aperture of finder scope included in millimeters.
Focuser size: Inner diameter of focuser drawtube in inches.

Limiting magnitude / Resolution: Magnitude of faintest star visible with telescope / Maximum resolution in arcseconds.
Magnification / Field of view: magnification with a 25mm eyepiece / Field of view in degrees with 25mm 60° apparent field eyepiece.
Special features: A (antireflection coated), C (carrying case), E (enhanced reflection coated), F (fiber glass tube), G (guidescope), H (heavy-duty mounting), M (metal tube), O (open tube), P (polar alignment finder), R (rotating tube), S (spiral paper tube), T (tripod), X (computer controlled).
n/a: Information not available.

Manufacturer and model	Aperture (inches)	Focal ratio	Type of optics	Mounting type	Clock drive	Slow motion	Setting circles	Drive corrector	Eyepieces	Finder scope	Focuser size	Total weight	Limiting magnitude / Resolution	Magnification / Field of view	Manufacturer's retail list price	Features
PARKS																
PRT-1	2.4	11.7	ACH	AA	—	—	—	—	1	5x	1.25	11	10.5/1.9	28/2.1	$400	AMT
PRT-2	2.4	11.7	ACH	AA	—	✓	—	—	1	10x	1.25	12	10.5/1.9	28/2.1	$525	AMT
PRT-46	2.4	15.2	ACH	GE	—	✓	—	—	1	10x	1.25	25	10.5/1.9	36/1.7	$800	AMHT
PENTAX																
65	2.6	10.8	ACH	GE	—	✓	✓	—	2	6x	1.48	26	10.6/1.8	28/2.1	$1,285	PT
65ED	2.6	10.8	2APO	GE	—	✓	✓	—	2	6x	1.48	26	10.6/1.8	28/2.1	$1,470	PT
75ED HF	3	6.7	APO	GE	—	✓	✓	—	2	6x	1.48	26	10.9/1.5	20/3	$1,660	PT
85	3.4	11.8	ACH	GE	—	✓	✓	—	3	6x	1.48	47	11.7/1.3	40/1.5	$2,325	PT
85ED	3.4	11.8	2APO	GE	—	✓	✓	—	3	6x	1.48	47	11.7/1.3	40/1.5	$2,820	PT
100	4	11.8	ACH	GE	—	✓	✓	—	5	6x	1.48	52	12.0/1.1	48/1.3	$3,350	GPT
100ED	4	11.8	2APO	GE	—	✓	✓	—	5	6x	1.48	52	12.0/1.1	48/1.3	$4,170	GPT
SWIFT																
Aerolite 863	2.4	13.3	ACH	AA	—	✓	—	—	3	6x24	.965	10	10.5/1.9	32/1.9	$360	T
859	2.4	15	ACH	GE	—	✓	✓	—	3	6x30	.965	25	10.5/1.9	36/1.7	$675	T
TAKAHASHI																
FC-50	2	8	FL/APO	—	—	—	—	—	—	6x30	1.34	32	11.1/2.3	16/3.3	$569	AM
FC-76FS	3	7.9	FL/APO	GE	W	✓	✓	✓	2	7x50	2	44	11.0/1.5	24/2.5	$1,995	AMPT
FCT-76	3	6.4	FL/APO	GE	W	✓	✓	✓	2	7x50	2.4	44	11.0/1.5	20/3.1	$3,095	AMPT
FC-100H	4	8	FL/APO	GE	W	✓	✓	✓	1	7x50	2.75	68	12.0/1.1	32/1.9	$3,995	AMPT
FCT-100F	4	6.4	FL/APO	GE	W	✓	✓	✓	2	7x50	2.75	68	12.0/1.1	26/2.3	$4,895	AMPT
FC-125S	5	8	FL/APO	GE	W	✓	✓	✓	2	11x70	4	198	12.7/0.9	40/1.5	$9,995	AHMPT
TASCO																
17TR	3.1	11.3	ACH	GE	—	✓	✓	—	3	6x30	.965	32	11.0/1.5	36/1.6	$928	RT
TELEVUE																
Oracle 3	3	7.4	APO	—	—	—	—	—	1	—	2	6	11.0/1.5	24/2.5	$995	ACEMR
Renaissance	4	5.5	APO	—	—	—	—	—	1	—	2	13	12.0/1.1	22/2.7	$1,995	ACEMR
Genesis	4	5	APO	—	—	—	—	—	1	—	2	10	12.0/1.1	20/2.8	$1,995	ACEMR
TR INC.																
60KT	2.4	15	ACH	GE	W	✓	✓	✓	2	6x30	1.25	n/a	10.5/1.9	36/1.7	$1,442	WT
80KU	3.1	12.5	ACH	GE	W	✓	✓	—	2	6x30	1.25	n/a	11.0/1.5	40/1.5	$1,599	WT
80KW	3.1	15	2APO	GE	W	✓	✓	✓	3	6x30	1.25	n/a	11.0/1.5	48/1.3	$2,150	WT
100KX	4	13	ACH	GE	W	✓	✓	—	3	6x30	1.25	n/a	12.0/1.1	52/1.2	$2,239	WT
UNITRON																
128	2.4	15	ACH	GE	W	✓	✓	—	2	6x24	1.25	24	10.5/1.9	36/1.7	$1,125	ACMT
142	3	16	ACH	GE	W	✓	✓	—	3	8x30	1.25	46	11/1.5	48/1.2	$1,950	ACMT
152	4	15	ACH	GE	W	✓	✓	—	4	10x42	1.25	100	12/1.1	60/1	n/a	ACMT
VERNONSCOPE																
Brandon Apo.	3.7	7	APO	AA	—	✓	—	—	1	—	2	24	11.5/1.3	13.3/3.8	$2,285	MTRCA
Brandon Apo.	3.7	7	APO	GE	✓	✓	✓	—	1	8x40	2	35	11.5/1.3	21.7/2.3	$3,050	MTRCA
Brandon Apo.	5.1	8	APO	AA	—	✓	—	—	1	—	2	48	12.7/0.9	41/1.5	$3,990	MTRCA
Brandon Apo.	5.1	8	APO	GE	✓	✓	✓	—	1	10x40	2	74	12.7/0.9	41/1.5	$5,400	MTRCA

CATADIOPTRICS

Manufacturer and model	Aperture (inches)	Focal ratio	Type of optics	Mounting type	Clock drive	Slow motion	Setting circles	Drive corrector	Eyepieces	Finder scope	Focuser size	Total weight	Limiting magnitude / Resolution	Magnification / Field of view	Manufacturer's retail list price	Features
CELESTRON INTERNATIONAL																
Classic 8	8	10	SCT	EF	S	✓	✓	—	1	6x30	1.25	22	13.9/0.6	80/0.7	$1,398	EM
SP-C8	8	10	SCT	GE	W	✓	✓	—	1	6x30	1.25	44	13.9/0.6	80/0.7	$2,048	AEMPT
Powerstar 4	8	10	SCT	EF	W	✓	✓	✓	2	8x50	1.25	46	13.9/0.6	80/0.7	$2,758	ACEMPT
Ultima 8	8	10	SCT	EF	W	✓	✓	✓	2	8x50	1.25	66	13.9/0.6	80/0.7	$3,328	ACEHMPT
Compustar 8	8	10	SCT	EF	W	✓	✓	✓	1	8x50	2	42	13.9/0.6	80/0.7	$6,000	ACEMPX
C11	11	10	SCT	EF	W	✓	✓	✓	1	8x50	2	56	14.5/0.4	112/0.5	$6,000	ACEMP
Compustar 11	11	10	SCT	EF	W	✓	✓	✓	1	8x50	2	66	14.5/0.4	112/0.5	$12,000	ACEMPX
C14	14	11	SCT	EF	W	✓	✓	—	4	8x50	2	112	15.1/0.3	156/0.4	$13,200	ACEMP
Compustar 14	14	11	SCT	EF	W	✓	✓	✓	4	8x50	2	122	15.1/0.3	156/0.4	$20,000	ACEMPX
MEADE INSTRUMENTS CORPORATION																
2045	4	10	SCT	EF	W	✓	✓	—	1	5x24	1.25	13	12.0/1.2	40/1.5	$1,200	EMA
MTS-SN6	6	5	SN	EF	W	—	✓	—	1	—	1.25	42	13.4/0.8	30/2.0	$950	FT
MTS-SN8	8	4	SN	EF	W	—	✓	—	1	—	1.25	52	13.9/0.6	32/1.9	$1,400	FT
MTS-SC8	8	10	SCT	EF	W	—	✓	—	1	6x30	1.25	50	13.9/0.6	80/0.7	$1,400	MT
2080	8	10	SCT	EF	W	✓	✓	—	1	6x30	1.25	48	13.9/0.6	80/0.7	$2,000	HMTE
2080/LX3	8	10	SCT	EF	W	✓	✓	—	1	8x50	1.25	52	13.9/0.6	80/0.7	$2,500	CHMTEA
2080/LX5	8	10	SCT	EF	W	✓	✓	✓	1	9x60	1.25/2	52	13.9/0.6	80/0.7	$3,600	CHMTE
2080/LX6	8	6.3	SCT	EF	W	✓	✓	✓	1	9x60	1.25/2	52	13.9/0.6	51/1.2	$3,900	CHMTEX
MTS-SC10	10	10	SCT	EF	—	—	—	—	1	8x50	1.25	80	14.2/0.5	100/0.6	$2,500	MT
2120/LX3	10	10	SCT	EF	W	✓	✓	—	1	8x50	1.25	73	14.2/0.5	100/0.6	$3,000	CHMTEA
2120/LX5	10	10	SCT	EF	W	✓	✓	✓	1	9x60	1.25/2	73	14.2/0.5	100/0.6	$4,200	CHMTEA
2120/LX6	10	6.3	SCT	EF	W	✓	✓	✓	1	9x60	1.25/2	52	14.2/0.5	64/0.9	$4,500	CHMTEX
2120/LX6 SW	10	6.3	SCT	EF	W	✓	✓	✓	1	9x60	1.25/2	93	14.2/0.5	64/0.9	$4,900	CHMTEX
PARKS																
Jovian-4	4	10	SCT	—	—	—	—	—	1	5x	1.25	4	12/1.1	40/1.5	$1,200	CME
QUESTAR CORPORATION																
Questar 3.5	3.5	14.4	MAK	EF	S	✓	✓	—	2	6x	1.25	7	12/1.4	52/1.0	$3,100	ACEHMT
Questar 7	7	14.4	MAK	EF	W	✓	✓	—	2	12x	1.25	53	13.7/0.7	106/0.5	$11,575	ACEHMT
Questar 12	12	15	MAK	GE	W	✓	✓	✓	2	12x	2.0	190	14.6/0.4	183/0.3	$53,000	AEHM
SWIFT																
854	3.1	12.5	SCT	EF	—	✓	✓	—	3	4x20	1.25	9	n/a	n/a	$885	CM
856	4.5	8.7	SN	GE	—	✓	✓	—	2	6x30	.965	21	12.5/1.0	40/1.4	$798	RT
TAKAHASHI																
ε-160	6.3	3.3	HA	GE	W	✓	✓	✓	—	7x50	2.25	60	13.5/0.8	21/2.8	$3,995	EMPT
ε-200	7.9	4	HA	GE	W	✓	✓	✓	—	7x50	3.25	160	13.9/0.6	32/1.8	$6,695	EMPT
ε-250	9.8	3.4	HA	—	—	✓	✓	✓	—	11x70	4	75	14.2/0.5	34/1.7	$7,850	EM
ε-300	11.8	3.7	HA	—	—	—	—	—	—	11x70	4	108	14.5/0.4	45/1.3	$8,975	EM

Type of optics: ACH (achromat), APO (apochromat), 2APO (two-element apochromat), CAS (Cassegrain), FL (calcium fluoride), HA (hyperbolic astrograph), MAK (Maksutov-Cassegrain), NEWT (Newtonian), SCT (Schmidt-Cassegrain), SN (Schmidt-Newtonian).
Mounting type: AA (altazimuth), DOB (Dobsonian), EF (equatorial fork), GE (German equatorial).
Clock drive: W (worm-gear drive), S (spur-gear drive).
Finder scope included: Magnification and aperture of finder scope included in millimeters.
Focuser size: Inner diameter of focuser drawtube in inches.

Limiting magnitude / Resolution: Magnitude of faintest star visible with telescope / Maximum resolution in arcseconds.
Magnification / Field of view: magnification with a 25mm eyepiece / Field of view in degrees with 25mm 60° apparent field eyepiece.
Special features: A (antireflection coated), C (carrying case), E (enhanced reflection coated), F (fiber glass tube), G (guidescope), H (heavy-duty mounting), M (metal tube), O (open tube), P (polar alignment finder), R (rotating tube), S (spiral paper tube), T (tripod), X (computer controlled).
n/a: Information not available.

ready and waiting to be taken outside will get used whenever the night is clear.

Another critical factor that limits the scope you can get is cost. How much you will spend on a telescope depends on many factors including your preferences, your income, and the importance of other expenses in your life. If you're buying your first telescope, start conservatively. Don't buy a telescope that strains the family budget. And don't pay so much that you feel bad if you're not outside with it on every clear night. Instead, select a telescope that will let you sample the wonders of the universe. If you uncover a deep interest, you can always buy a bigger telescope next year.

Deciphering Manufacturers' Specs

Because the telescope market is loaded with telescopes spanning a large price range, each giving a slightly different combination of performance and ease of use, we have compiled data for telescopes in the accompanying tables. Altogether, we summarize features for 147 models produced by 24 different manufacturers. The information appears separately for catadioptrics, refractors, and reflectors, letting you compare and contrast different models.

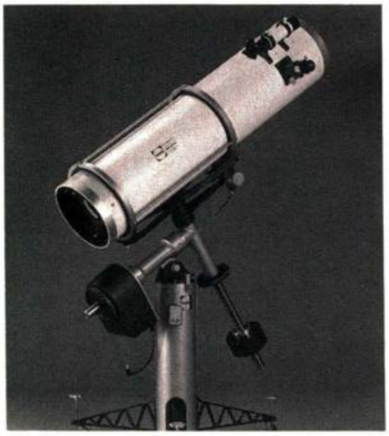
Aperture. This is the diameter of the telescope's primary mirror or lens. Generally, the larger the aperture, the better the views. Large telescopes cost more than small ones and are correspondingly more difficult to work with. These factors set a practical limit on the aperture you will be able to handle.

The entry in this column gives the aperture of the instrument in inches, though some manufacturers specify apertures in millimeters. To convert, remember that 1 inch equals 25.4 millimeters. As a quick rule of thumb, 2.4 inches equals about 60mm, 3.1 inches is 80mm, 3.6 inches is 90mm, and 4 inches is 100mm.

Focal ratio. Focal ratio is the effective focal length of a telescope divided by its aperture. The number generally indicates the tasks that the telescope will perform best. Telescopes with focal ratios between f/3.5 and f/5 are generally intended for deep-sky viewing at low magnification or for wide-field astrophotography. Focal ratios between f/5 and f/11 — the "all around" ones — are typical of telescopes for general observing. And focal ratios of f/11 or greater are best for viewing the Moon, planets, and double stars at relatively high magnification.

Type of optics. Reflectors may have Newtonian (NEWT) or Cassegrain (CAS) optical systems, although most reflectors made today are Newtonians. Cassegrain reflectors are similar to Schmidt-Cassegrains, but their optical design does not include the corrector plate the Schmidt-Cassegrains have. A few manufacturers now offer reflector telescopes with both Newtonian and Cassegrain focuses, so they can be used at f/5 and f/12, for example. Wide- and narrow-field views of objects are both possible with these systems.

We list several types of refractors: achromatic lens refractors (ACH), apochromatic lens refractors (APO), two-element apochromats (2APO), and fluorite lens refractors (FL). Most achromatic lens refractors have slight residual chromatic aberration. In small- and medium-sized refractors, only an expert can spot it. In large achromats, however, bright objects have purplish haloes.



Parks' 10-inch f/5 Newtonian

We list four types of catadioptric telescopes: Schmidt-Cassegrains (SCT), Maksutov-Cassegrains (MAK), Schmidt-Newtonians (SN), and hyperbolic astrographs (HA). The SCTs and MAKs are compact long focal ratio systems designed for portability and versatility.

Both Schmidt-Newtonians and hyperbolic astrographs are similar to ordinary Newtonians. In the former the mirror's reflecting surface has a spherical figure and a corrector plate for keeping star images sharp over a wide field of view. In the latter a group of lenses placed just ahead of the focus removes the residual aberrations of the primary mirror, resulting in an instrument well suited for prime-focus astrophotography.

Mounting type. The four most common types are the German equatorial (GE), the equatorial fork (EF), the Dobsonian (DOB), and the altazimuth (AA). We recommend an equatorial or a Dobsonian mount for a first telescope intended for an adult amateur astronomer.

Clock drive. Equatorial mountings may include a clock drive, a small motor that turns the telescope at a rate equal to that of Earth's rotation. When the telescope is aligned with the north celestial pole, the clock drive keeps the object you're observing centered in the field of view. We distinguish between two types of clock drives: those with worm gears (W) and those with spur gears (S). Generally, worm gears are smoother and more precise than spur gears. If the telescope's mount has no drive, the column has a dash.

Slow-motion controls. Slow-motion controls are essential for high-power observing or astrophotography. These are little slewing motors or manual knobs that allow fine adjustments of the telescope's position. Slow-motion controls let you precisely center anything you're viewing with the turn of a knob and permit tracking corrections in astrophotography.

If slow-motion controls are included in the telescope's purchase price, you'll see a check mark in this column. If there is no check mark, optional slow-motion controls may be available at extra cost — consult the manufacturer.

Setting circles. Equatorial telescopes may come equipped with setting circles, precisely marked protractorlike measuring scales. If they are included in the price of the telescope, you'll find a check mark. If not, you'll find a dash.

Drive corrector. No clock drive runs perfectly. Even the best worm gears suffer from some periodic errors as they run. For astrophotography, where tracking errors ruin a photograph, you'll need some means to accurately track. If the telescope includes a drive corrector, you'll see a check mark in this column.

Eyepieces included. This column gives the number of eyepieces included in the purchase price of the telescope — or a dash if none are included.

Finder scope. A finder scope, a tiny refractor mounted on the main telescope, allows you to quickly point the main telescope at a bright star or locate the area of a faint galaxy. If the telescope includes a finder, you'll see its optical specifications listed in this column. For example, an 8x50 finder has an objective lens of 50mm diameter and a magnifying power of 8x. We recommend you buy a finder scope if one is not supplied with the telescope. For ease of use, we recommend a finder scope in the 8x50 range.

Focuser size. The telescope's focuser must accept the eyepieces you will use. Standard eyepieces have a barrel diameter of 1.25 inches. If you are seriously interested in deep-sky viewing or astrophotography, consider getting a telescope with a 2-inch focuser that comes with an adaptor to accommodate 1.25-inch eyepieces. Some small refractors have focuser tubes that accept 0.965-inch eyepieces. These eyepieces generally are of poor quality, and we suggest purchasing an adaptor to convert to 1.25-inch eyepieces.

Total weight. Most adults can handle a scope that weighs fifty pounds, especially if the telescope breaks down into two or more components. Large telescopes weigh as much as several hundred pounds and require a truck and at least two people to handle. If you're buying your first telescope, make a sensible choice. We recommend avoiding instruments that weigh more than half of what you do!

Limiting magnitude / Resolution. This column gives the magnitude of the faintest star you are likely to see with the telescope and the theoretical limit of resolution. These figures are approximations that provide a calibrated scale of comparison. Under an exceptionally dark sky, you may see stars fainter than the limiting magnitude suggests. Conversely, if you're observing under a light-polluted sky you may not be able to reach this limit. Likewise, less-than-perfect seeing conditions limit the resolution you will be able to achieve.

Magnification / Field of view. To help you place the focal lengths of various telescopes in perspective, we have calculated the magnification and true field of view for each system when used with a 25mm eyepiece with an apparent field of 60°. When comparing fields of view, remember that the Pleiades star cluster measures nearly 2° across and the Moon spans 0.5°.

Manufacturer's retail list price. The price given here is the catalog list from the factory. However, "street prices" from dealers usually fall below this figure — often far below. The retail list price lets you make relative comparisons; but when you go to buy, it will pay to shop around. To obtain current prices, check the ads in ASTRONOMY or call your local telescope dealer.

Features. Major features that come with each make and model are listed, and a key to the codes appears at the bottom of each table. In many cases the same basic model is available with more or less features with correspondingly higher or lower prices. Consult manufacturers or your local dealer for a detailed explanation of available accessory packages.

How to Begin the Telescope Hunt

To decide which telescope is best for you, make an educated guess on your future observing needs and interests, establish an aperture range (without neglecting practical limitations like transport), and set a limit on how much you want to spend.

If you're in doubt about which scope among several to get, be conservative. The best strategy for buying a first scope is to get a well-made, basic telescope and outfit it with additional accessories as you actually need them.

Meade's 2080/LX5 Schmidt-Cassegrain

Before you write the check, do a final survey. Get the manufacturers' catalogs, which contain more detailed information for specific models you are interested in. These will help you hone your "want list" and, given some careful thought, narrow it down to the best choice.

REFLECTORS

Reflecting telescopes are the real workhorses of backyard astronomy. They offer more variety and flexibility than any other design. Reflectors also let you choose a Dobsonian mounting for simple viewing or a heavy-duty deluxe equatorial mount for astrophotography.

No matter what your observing interests, the bottom line is that reflectors cost less per inch of aperture than other telescopes. If you are a deep-sky observer with an interest in getting the greatest aperture for your money, you'll want a reflector.

If you want an all-around telescope with a moderate focal ratio, take a close look at small- or medium-sized Newtonian reflectors. These telescopes offer a fair compromise between the ability to show faint objects at low and medium powers and the demands of portability.

If you're not interested in astrophotography and want the maximum aperture for viewing faint objects, consider a reflector on a Dobsonian mount. Three companies (Coulter Optical, Sky Designs, and Tectron) offer Dobsonians, ranging in price from $239 for Coulter's 8-inch f/4.5 system to $6,575 for Tectron's 25-inch f/5 telescope. (Note that Coulter's telescopes do not come with a finder scope, an item you'll want to add right away.) All three companies offer a range of apertures. Coulter's largest is a 17.5-inch f/4.5 model that sells for $995. The smallest models by Sky Designs and Tectron are a 14.5-inch f/4.5 model ($1,699) and a 20-inch f/5 model ($3,695), respectively.

A Dobsonian telescope is optimized for low-power viewing. If you look at an object at high powers with a Dobsonian, it becomes difficult and somewhat annoying to keep the object centered in the field of view. If you're going to spend a lot of time looking at planets or other objects that call for high-power views, you'll want an equatorially mounted telescope with a clock drive.

An equatorial mounting increases the price, but it also opens the alternatives to many different models. Basically, you can choose anything from a Tasco 11TR 4.5-inch f/7.9 scope ($520) to Star Liner's 16-inch f/5 Observatory telescope ($19,000).

Surprisingly, small reflecting telescopes are relatively few. In the low-price range, Celestron's 4.5-inch f/7.9 reflector ($798); Edmund's 6-inch f/6 reflector ($779); and Telescopics' RFT-6 6-inch f/5 reflector ($365) have moderate focal ratios and equatorial mountings.

More sophisticated, more expensive reflectors include a wide range of sizes and capabilities. Representative models include Meade's DS-10 10-inch f/4.5 reflector ($1,400); Takahashi's MT-100P 4-inch f/6 reflector ($1,595); TR's 100 NU 4-inch f/10 model ($1,708); and Parks' 8-inch f/3.5 Petra ($3,500).

Not all reflectors are Newtonians. Star Liner and RVR offer Cassegrain reflectors. With multiple-folded light paths, Cassegrain telescopes have long focal lengths (and f/ratios) and therefore behave rather like refractors. Examples are Star Liner's 10-inch f/12 Quality Cassegrain ($3,650) and the SG-0 17.7-inch f/12 Cassegrain system by ASKO (distributed by RVR Optical),

Manufacturer and model	Aperture (inches)	Focal ratio	Type of optics	Mounting type	Clock drive	Slow motion	Setting circles	Drive corrector	Eyepieces	Finder scope	Focuser size	Total weight	Limiting magnitude / Resolution	Magnification / Field of view	Manufacturer's retail list price	
CELESTRON INTERNATIONAL																
C4.5	4.5	7.9	NEWT	GE	W	✓	✓	—	1	5x24	1.25	28	12.5/1.0	36/1.6	$798	AEMRT
COULTER OPTICAL																
Odyssey 8	8	4.5	NEWT	DOB	—	—	—	—	1	—	1.25	39	13.9/0.6	36/1.6	$239	S
Odyssey Compact	10.1	4.5	NEWT	DOB	—	—	—	—	1	—	1.25	65	14.2/0.5	46/1.3	$299	S
Odyssey 1	13.1	4.5	NEWT	DOB	—	—	—	—	1	—	1.25	100	14.8/0.4	60/1.0	$499	S
Odyssey 2	17.5	4.5	NEWT	DOB	—	—	—	—	1	—	1.25	206	15.8/0.3	80/0.7	$995	S
DOBBINS INSTRUMENT COMPANY																
8″ f/7.5	8	7.5	NEWT	GE	W	✓	✓	✓	—	8x50	2	90	13.9/0.6	65/0.9	$2,970	GHMPR
10″ f/6	10	6	NEWT	GE	W	✓	✓	✓	—	8x50	2	100	14.2/0.5	81/0.7	$3,270	GHMPR
12″ f/6	12	6	NEWT	GE	W	✓	✓	✓	—	12x80	2	165	13.9/0.6	162/0.4	$8,135	GHMPR
EDMUND SCIENTIFIC																
Astroscan 2001	4.1	4.2	NEWT	—	—	—	—	—	1	—	1.25	10.7	12.0/1.0	18/3.3	$379	—
6-inch #3011	6	6	NEWT	GE	W	✓	✓	—	1	7x30	1.25	65	13.4/0.7	36/1.6	$795	R
JIM'S MOBILE																
NGT 18	18	4.5	NEWT	GE	W	✓	✓	✓	1	8x50	2	180	15.7/0.2	82/1.4	$7,400	HMPRT
MEADE INSTRUMENTS CORPORATION																
826C	8	6	NEWT	GE	W	—	✓	—	2	8x50	1.25/2	75	13.9/0.6	48/1.25	$1,590	FORT
880	8	6	NEWT	GE	W	—	✓	—	2	8x50	1.25/2	162	13.9/0.6	48/1.2	$2,900	FHORT
DS-10	10	4.5	NEWT	GE	—	—	—	—	1	—	1.25	72	14.2/0.5	45/1.3	$1,400	OST
1060	10	6	NEWT	GE	W	—	✓	—	2	8x50	1.25/2	208	14.2/0.5	61/0.9	$3,440	FHORT
1266	12	6	NEWT	GE	W	—	✓	—	2	8x50	1.25/2	273	14.5/0.4	73/0.8	$4,800	FHORT
DS-16	16	4.5	NEWT	GE	—	—	—	—	1	—	1.25	225	15.5/0.3	73/0.8	$2,750	OST
PARKS																
6″ f/8 Precision	6	8	NEWT	GE	—	—	—	—	1	6x30	1.25	80	13.4/0.7	49/1.2	$1,400	FR
8″ f/6 Precision	8	6	NEWT	GE	—	—	—	—	1	6x30	1.25	95	13.9/0.6	49/1.2	$1,800	FR
8″ f/3.5 Petra	8	3.5	NEWT	GE	W	✓	✓	✓	1	8x50	2	75	13.9/0.6	28/2.2	$3,500	FHRT
8″ f/6 Superior	8	6	NEWT	GE	W	✓	✓	✓	2	8x50	2	250	13.9/0.6	49/1.2	$3,900	FHR
10″ f/5 Superior	10	5	NEWT	GE	W	✓	✓	✓	2	8x50	2	300	14.2/0.5	50/1.2	$4,400	FHR
10″ f/3.5 Petra	10	3.5	NEWT	GE	W	✓	✓	✓	1	8x50	2	80	14.2/0.5	36/1.7	$4,500	FHRT
12.5″ f/5 Superior	12.5	6	NEWT	GE	W	✓	✓	✓	2	8x50	2	350	14.7/0.4	76/0.7	$5,500	FHR
16″ f/5 Observatory	16	6	NEWT	GE	W	✓	✓	✓	2	8x50	2	600	15.5/0.3	97/0.6	$19,000	FHR
RVR/ASKO																
SE	12.2	12	CAS	GE	W	✓	✓	✓	7	8x50	2	1100	14.2/0.1	149/0.4	$43,500	GHM
SA 400	15.7	16	CAS	GE	W	✓	✓	✓	4	8x50	4	1550	15.5/0.3	255/0.2	$86,600	GHM
SG-0	17.7	12	CAS	GE	W	✓	✓	✓	4	8x50	4	3000	15.8/0.3	215/0.3	$186,000	GHM

Type of optics: ACH (achromat), APO (apochromat), 2APO (two-element apochromat), CAS (Cassegrain), FL (calcium fluoride), HA (hyperbolic astrograph), MAK (Maksutov-Cassegrain), NEWT (Newtonian), SCT (Schmidt-Cassegrain), SN (Schmidt-Newtonian).
Mounting type: AA (altazimuth), DOB (Dobsonian), EF (equatorial fork), GE (German equatorial).
Clock drive: W (worm-gear drive), S (spur-gear drive).
Finder scope included: Magnification and aperture of finder scope included in millimeters.
Focuser size: Inner diameter of focuser drawtube in inches.

Limiting magnitude / Resolution: Magnitude of faintest star visible with telescope / Maximum resolution in arcseconds.
Magnification / Field of view: magnification with a 25mm eyepiece / Field of view in degrees with 25mm 60° apparent field eyepiece.
Special features: A (antireflection coated), C (carrying case), E (enhanced reflection coated), F (fiber glass tube), G (guidescope), H (heavy-duty mounting), M (metal tube), O (open tube), P (polar alignment finder), R (rotating tube), S (spiral paper tube), T (tripod), X (computer controlled).
n/a: Information not available.

REFLECTORS

Manufacturer and model	Aperture (inches)	Focal ratio	Type of optics	Mounting type	Clock drive	Slow motion	Setting circles	Drive corrector	Eyepieces	Finder scope	Focuser size	Total weight	Limiting magnitude / Resolution	Magnification / Field of view	Manufacturer's retail list price	Features
SKY DESIGNS																
14.5	14.5	4.5	NEWT	DOB	—	—	—	—	—	—	2	88	15.0/0.3	66/0.9	$1,699	O
18	18	4.5	NEWT	DOB	—	—	—	—	—	—	2	138	15.7/0.2	80/0.7	$2,250	O
20	20	4	NEWT	DOB	—	—	—	—	—	—	2	168	18.5/0.2	81/0.7	$3,250	O
STAR LINER																
6″ Standard	6	8	NEWT	GE	—	—	✓	—	2	6x30	1.25	60	13.4/0.7	49/1.2	$995	FR
6″ Delux	6	8	NEWT	GE	W	—	✓	—	2	6x30	1.25	70	13.4/0.7	49/1.2	$1,350	FR
8″ Standard	8	7	NEWT	GE	—	—	✓	—	2	6x30	1.25	85	13.9/0.6	57/1.0	$1,295	FR
8″ Delux	8	7	NEWT	GE	W	—	✓	—	2	6x30	1.25	85	13.9/0.6	57/1.0	$1,675	FR
6″ Richfield	6	4	NEWT	GE	W	—	✓	—	2	7x30	1.25	70	13.4/0.7	24/2.5	$1,995	FHR
8″ Quality	8	7	NEWT	GE	W	—	✓	—	2	7x50	1.25	95	13.9/0.6	57/1.0	$2,330	FR
8″ f/12 Quality	8	12	CAS	GE	W	—	✓	—	3	6x30	1.25	120	13.9/0.6	97/0.6	$2,690	FHR
10″ f/12 Quality	10	12	CAS	GE	W	—	✓	—	3	10x50	2	160	14.2/0.5	122/0.5	$3,650	FHR
10″ f/10 Cass.	10	10	CAS	EF	W	—	✓	—	3	10x50	2	145	14.2/0.5	101/0.6	$3,650	FHR
12.5″ f/12 Quality	12.5	12	CAS	GE	W	—	✓	—	3	10x50	2	240	14.7/0.4	152/0.4	$4,590	FHR
14.25″ f/10 Cass.	14.2	12	CAS	EF	W	—	✓	—	3	10x50	2	190	15/0.4	171/0.4	$8,500	FHR
16″ f/5 Observatory	16	5	NEWT	GE	W	—	✓	—	3	10x50	2	575	15.5/0.3	81/0.7	$19,000	FGHR
TAKAHASHI																
MT-100	4	6	NEWT	GE	W	✓	✓	—	—	6x30	1.25	34	12.0/1.2	24/2.5	$1,595	EMPT
MT-130	5	6.1	NEWT	GE	W	✓	✓	✓	—	6x30	2.25	46	12.7/0.9	31/2	$1,675	EMPT
MT-160	6.2	6.2	NEWT	GE	W	✓	✓	✓	—	7x50	2.25	67	13.4/0.7	40/1.5	$3,250	EMPT
MT-200	8	6	NEWT	GE	W	✓	✓	✓	—	11x70	3.25	165	13.9/0.6	49/1.2	$5,995	EMPT
MT-250	9.8	4.8	NEWT	—	—	—	—	—	—	11x70	4	85	14.2/0.5	48/1.2	$6,350	EM
TASCO																
11TR	4.5	7.9	NEWT	GE	—	✓	✓	—	2	5x24	.965	29	12.5/1.0	36/1.6	$520	RT
TECTRON																
20″	20	5	NEWT	DOB	—	—	—	—	—	—	2	150	18.5/0.2	102/0.6	$3,695	SO
25″	25	5	NEWT	DOB	—	—	—	—	—	—	2	250	18.8/0.2	127/0.5	$6,575	SO
TELESCOPICS																
RFT-6	6	5	NEWT	—	—	—	—	—	—	—	1.25	10	13.4/0.7	30/2	$365	EM
RFT-8	8	5	NEWT	—	—	—	—	—	—	—	2	20	13.9/0.6	41/1.5	$550	EM
RFT-10	10	5	NEWT	—	—	—	—	—	—	—	2	33	14.2/0.5	51/1.2	$895	EM
RFT-14	14.5	5	NEWT	—	—	—	—	—	—	—	2	65	15/0.3	73/0.8	$2,295	EM
TR INC.																
100 NQ	4	6	NEWT	GE	W	✓	✓	✓	3	6x30	1.4	n/a	12.0/1.2	24/2.5	$1,685	RT
100 NU	4	10	NEWT	GE	W	✓	✓	✓	2	6x30	1.4	n/a	12.0/1.2	41/1.4	$1,708	RT

Type of optics: ACH (achromat), APO (apochromat), 2APO (two-element apochromat), CAS (Cassegrain), FL (calcium fluoride), HA (hyperbolic astrograph), MAK (Maksutov-Cassegrain), NEWT (Newtonian), SCT (Schmidt-Cassegrain), SN (Schmidt-Newtonian).
Mounting type: AA (altazimuth), DOB (Dobsonian), EF (equatorial fork), GE (German equatorial).
Clock drive: W (worm-gear drive), S (spur-gear drive).
Finder scope included: Magnification and aperture of finder scope included in millimeters.
Focuser size: Inner diameter of focuser drawtube in inches.

Limiting magnitude / Resolution: Magnitude of faintest star visible with telescope / Maximum resolution in arcseconds.
Magnification / Field of view: magnification with a 25mm eyepiece / Field of view in degrees with 25mm 60° apparent field eyepiece.
Special features: A (antireflection coated), C (carrying case), E (enhanced reflection coated), F (fiber glass tube), G (guidescope), H (heavy-duty mounting), M (metal tube), O (open tube), P (polar alignment finder), R (rotating tube), S (spiral paper tube), T (tripod), X (computer controlled).
n/a: Information not available.

an observatory-grade instrument that retails for a whopping $186,000.

Our table lists fewer than half of the available models of reflectors. Given the enormous number of accessories and features, a complete list would fill many pages. Contact the manufacturers or a local telescope dealer to check the full list of alternatives. You may discover that you can customize a model to match your exact requirements.

REFRACTORS

For decades refractors have taken a back seat to the two other types of telescopes in the minds of amateur astronomers. However, over the past few years more and more amateurs have come to appreciate the capabilities of refractors.

The change resulted from amateurs discovering that a new breed of refractors — especially apochromats and models made with fluorite lenses — deliver stunningly good images. Often a 3-inch or 4-inch apochromat provides crisper, more contrasty images than a 4-inch or 5-inch catadioptric. The foremost reason for this is the quality of refractor lenses. The current breed, especially the color-corrected apochromatic lenses, provide star images that appear incomparably crisp. Additionally, refractors have sealed tubes that minimize turbulence from air currents flowing in and out of the tube. Also, their optical paths are unobstructed by the secondary mirrors found in reflectors that introduce extra diffraction and scatter light across the field. Refractor apertures are limited to about 8 inches, however, although you can buy a 12-incher for a steep price.

It's possible to classify refractors into three groups based on their cost and marketing strategy. Small refractors have apertures between 50mm (2 inches) and 80mm (3 inches). These instruments typically come with a couple of eyepieces, a tripod, and a small finder scope. Typical models include Celestron's Firstscope 80, a 3.1-inch f/11.4 system ($850), and Jason Empire's 313, a 2.4-inch f/15 instrument ($480). (For an in-depth look at small refractors, see "ASTRONOMY Surveys Twelve Small Refractors" by Robert Burnham on page 80.)

Refractors with medium-sized lenses have sturdier, usually equatorial mountings. They typically have setting circles and larger finder scopes and often come with a clock drive. Prices range from Celestron's SP-C102 4-inch f/9.8 achromat ($1,900) to Vernonscope's 5.1-inch f/8 Brandon apochromat ($5,350).

The big refractors are finely crafted instruments with top-of-the-line optics that deliver sharp, contrasty images. Lenses are often apochromats, three-element systems that eliminate color fringing. Another design uses calcium fluoride lens elements to achieve color-free results.

Although we provide typical system prices for large refractors, these instruments are generally produced on a partially custom basis. You buy one of these telescopes by carefully choosing from a long list of components in the manufacturer's catalog. The end result is a superb instrument that performs impeccably.

Why shouldn't everyone get a fine refractor, then? Custom-made instruments carry custom-made prices. Astro-Physics' 6-inch f/9 Starfire apochromat retails for $2,680 for the optical tube assembly alone. You need to add a mounting to complete the package. A 10-inch f/10 achromat from Dobbins Instrument sells for $16,885, and a 12-inch f/15 achromat from Cheshire goes for $11,000 —without a mounting. Clearly, a large refractor is a substantial investment.

Tele Vue's Genesis 4-inch f/5 apochromatic refractor

Deep-sky enthusiasts might want to check the tables for instruments with focal ratios between 5 and 10. Examples include Cheshire's 5-inch f/5 achromat ($2,789); Astro-Physics' 5-inch f/8 Starfire apochromat ($1,850 without mount); and Tele Vue's Genesis 4-inch f/5 apochromat ($1,995).

CATADIOPTRICS

Combining the closed tube and long focal ratio of a standard refractor and the sheer aperture available in a Newtonian reflector, "cats" are perfect for anyone with a telescope transport or storage problem. (For an overview of the development of catadioptric telescopes, see "Genesis of a Legend" by Alan Dyer on page 86.)

Ranging from 3.5 inches (Questar) to 14 inches (Celestron) in aperture, catadioptrics are best known for being compact. While no 14-inch telescope could ever be described as small or light, a 14-inch catadioptric is smaller and lighter than a 14-inch Newtonian by at least a factor of two.

There are four distinct optical configurations in catadioptric telescopes — Schmidt-Newtonians, hyperbolic astrographs, Schmidt-Cassegrains, and Maksutov-Cassegrains. Schmidt-Newtonians are simple reflectors with a corrector plate added, allowing a very wide field of view. Examples of this type include Meade's MTS-SN6, a 6-inch f/5 Schmidt-Newtonian ($950), and Swift's model 856, a 4.5-inch f/8.7 Schmidt-Newtonian. A similar design called a hyperbolic astrograph uses a hyperbolic mirror combined with a corrector plate to yield sharp photos of large fields of view. The only hyperbolic astrographs on the market are those made by Takahashi, imported by the Texas Nautical Repair Co. These range from the ε-160, a 6.3-inch f/3.3 scope ($3,995) to the ε-300, an 11.8-inch f/3.7 instrument ($8,975).

Catadioptric telescopes are optimized for astrophotography, especially the Schmidt-Cassegrain telescope (SCT). These instruments use a parabolic mirror with a hole in its center, a corrector plate, and a secondary mirror that reflects light through the primary to an eyepiece at the back of the scope. Examples include Celestron's Ultima 8, an 8-inch f/10 SCT ($3,325); Meade's 2080 LX5, an 8-inch f/10 SCT ($3,600); and the Jovian-4 by Parks, a 4-inch f/10 SCT ($1,200).

Another type of catadioptric is the Maksutov-Cassegrain, an instrument that uses a spherical primary mirror and a deeply curved corrector plate to produce a long-focus system that gives sharp images. Questar Corporation is currently the only producer of commercial Maksutov telescopes. Their line ranges from a 3.5-inch f/14.4 model ($3,100) to a 12-inch f/15 system ($53,000).

Today's busy telescope market carries an astonishing number of makes and models. Whatever telescope you want — big, small, reflector, refractor, catadioptric — it's probably available at a "street price" that falls within the family budget. Before you write a big check, however, make sure that you know what you want, investigate all of the angles, and shop the market carefully. This done, you and your telescope will have many happy years to come. ☐

ASTRONOMY SURVEYS TWELVE SMALL REFRACTORS

Is the classic small refractor a good beginners' scope? Our tests show that only a few offer acceptable performance.

by Robert Burnham

Many people will buy their first telescope this year either for themselves or a child. We thought the time was appropriate to examine one kind of telescope widely assumed to be suitable for beginners: the small refractor.

This type of instrument virtually symbolizes amateur astronomy, because it looks just like what a backyard telescope *should* look like. Advertising picks up on this and encourages novices to think of these instruments as "starter scopes." This is far from the truth. We surveyed a dozen small refractors and found a great variety in optical quality. We also discovered that with a couple of exceptions, they come with shaky mountings and substandard eyepieces. Unsuspecting beginners do not have the experience to blame a telescope's shortcomings for the disappointing views that result and wind up concluding that amateur astronomy isn't much fun. This drives people away from a fascinating hobby.

Small refractors are sold in photography stores and often appear, at least seasonally, in outlets that don't normally stock astronomical telescopes, such as Target and K-Mart. We do not recommend that anyone buy a telescope from any of these outlets no matter how attractive the discount appears. The problem is that the store staff knows nothing about telescopes, and a buyer has no chance to examine the instrument until it is paid for and taken home. You are in a better position if you shop in a bona-fide telescope store because the staff is more knowledgeable, the stock is better selected, and you can unpack your intended instrument and check it out before you buy. Our findings told us that a prepurchase inspection — or a decent mail-order return policy —was a must.

We surveyed refractors with achromat (two-element) lenses in the 60mm (2.4 inch) and 80mm (3.2 inch) aperture ranges, the most common and most popular sizes, and examined instruments with altazimuth and equatorial mountings. We asked manufacturers to loan us off-the-shelf models identical to what anyone could buy. (In fact, we saw nothing that led us to suspect we received examples "doctored" for better than average performance.) A summary chart on page 82 rates the telescopes.

CLUMSY IN USE, this "side strut" slow motion on the Swift 863 has limited mobility, induces shakiness, and is difficult to manipulate.

We separated the telescopes into three groups: those with altazimuth mountings, 60mm aperture equatorials, and 80mm equatorials. (We judged the 3-inch Unitron with the 80mm instruments because it was close in size.) For each group we compared performance in two broad areas, mechanical and optical. Mechanical included such considerations as steadiness of the tripod, smoothness of the motions, ease of height adjustment, and the like. Optical concerned the objective (main) lens, the eyepieces supplied, and the finder scope.

We found that the objective lenses of most of the telescopes performed at least adequately and a couple were excellent. But in most cases, the quality of the objective was not apparent until the low-quality eyepieces supplied with the instruments were replaced with better ones and we had removed the telescope tube from its mounting and placed it on a firm bench for testing.

This told us that it is primarily mechanical performance, specifically the stability of the mounting, that sets good instruments apart from shoddy ones. Many of these telescopes were deficient in stability, some to the point of being unusable. Bad as it sounds, this outcome actually favors the buyer (provided he or she can handle the telescope before purchasing it), because mounting shakiness can easily be assessed right in the store.

Use this simple test. Slip in an eyepiece that gives about 100x, aim the scope at a distant object, and focus. Does the telescope hold steady enough to let you achieve a good focus, or do you have to guess at best focus and wait for the wiggles to die away before you can tell? Now tap on the tube and turn each of the slow motions, counting the seconds until the image stops moving. If the vibration takes longer than 2 or 3 seconds to die away, the mounting is too shaky for enjoyable viewing and will be a constant source of irritation. A telescope that won't sit still in a breeze is no bargain — whatever the price.

Altazimuth Mountings = Simplicity

There are two fundamental kinds of mountings: the altitude-azimuth and the equatorial. We'll deal with the former first because their cheaper price makes them more attractive to beginners.

The altazimuth mounting has a vertical axis that lets the telescope swing around the horizon, and a horizontal axis that lets it point up and down.

Rating the Small Refractors

Model	List Price	Aperture	F/ratio	Mounting	Mount	Stability	Optics
Celestron C60E	460	60	13.3	EQ	4	3	1
Celestron Firstscope	850	80	11.4	AA	4	3	3
Jason 307	280	60	13.3	AA	3	3	4
Jason 324	1,200	80	15	EQ	2	2	2
Meade 226	300	60	11.7	AA	1	4	5
Meade 291	570	60	15	EQ	3	3	2
Swift 863	370	60	13.3	AA	2	1	1
Swift 859R	650	60	15	EQ	3	4	1
Tasco 851TR	300	60	15	EQ	2	3	4
Tasco 17TR	1,200	80	11.3	EQ	2	2	3
Unitron 128	1,125	60	15	EQ	4	4	3
Unitron 142	1,950	75	16	EQ	4	4	5

List Price is suggested retail (the "street price" from dealers is often much less). *Aperture* is in millimeters. *F/ratio* is the focal length divided by aperture. *Mountings* are altazimuth (AA) or equatorial (EQ). *Mount*, *Stability*, and *Optics* ratings are based on a 1 to 5 scale, with 5 being best; a score of 3 in any category is the minimum acceptable. *Mount* denotes convenience of use. *Stability* is how wiggle-free the mounting is. The criteria for *Optics* is explained in the text.

Both axes have thumbscrew locking clamps and slow-motion control knobs to pivot the scope from side to side and up and down.

Because neither axis of an altazimuth mounting parallels the Earth's rotational axis, tracking a celestial object involves making continual adjustments of both slow motions. Even when the controls work with buttery smoothness, this takes practice. Typically, you keep an object centered in the field of view by a series of "stair-steps": up a bit, then right, then up, then right, and so on. This process is continued as the Earth's rotation carries the object out of the field of view on an angle. The problem of keeping an object centered is easy at 50x, distracting at 100x, and very difficult at 200x.

The altazimuth head is the metal part of the mounting that contains the controls. It stands at the apex of the tripod, whose wooden legs are adjustable in length. This creates a tradeoff: the longer the legs, the less you have to stoop to look into the eyepiece, but at the same time the more wiggly the tripod becomes. We tested all the telescopes (except the Unitrons, whose legs are fixed at full extension) with the legs extended halfway.

The legs attach to the head with bolts and wing nuts; washers prevent the bolt and nut from crushing the relatively soft wood when tightened firmly. We found a design defect in the 60mm Jason: vertical slits in the leg attachments. The slits allow part of the head to be squeezed and deformed slightly as the wing nuts are tightened (see photo on page 85), which reduces stability by preventing the tightest possible grip.

About a third of the way down from the apex on altazimuth mountings, a small tray of stamped metal braces the legs and also provides a shelf for parking spare eyepieces. This latter use is not a good idea, however, because eyepieces will collect dust, dew, or frost and could fall to the ground if anyone stumbles against the tripod. The tripod leg tips on the altazimuth scopes were plastic; Celestron's Firstscope has metal spikes, which are more durable and let the legs bite into the ground for a better grip.

Of the three 60mm altazimuth scopes we examined, only one showed adequate mechanical performance, the Jason model 307. This model has smooth slow-motion controls and a damping time for vibrations of 2 to 3 seconds, about average for all the scopes. The Swift Aerolite model 863 vibrated longer (4 seconds) and had an unacceptable 2° to 3° wobble in elevation that we could not eliminate no matter how the locks were tightened. (We also felt its "side strut" elevation control [see photo on page 80] was much less convenient to use than an ordinary slow-motion knob.) The Meade model 226 shed vibration the quickest (1 to 2 seconds), but it had no slow-motion controls. To follow a celestial object the viewer has to swing the tube by hand, which is difficult to do precisely. While this is acceptable for a terrestrial spotting scope, it isn't in an instrument for amateur astronomy.

Celestron's Firstscope was the only 80mm altazimuth telescope we tested. Its tripod damped vibrations in 2 seconds, and its slow motions had a "springy" feel with a small amount of backlash in azimuth: when the knob is turned, the telescope doesn't respond instantly but has a fractional pause. Both motions, however, worked smoothly, and the metal-spike tripod tips made good contact with unpaved ground.

We do not recommend altazimuth telescopes for beginning amateur astronomers because the mountings have limitations in tracking celestial objects that users quickly tire of. However, the Jason 307 may be acceptable for someone with an extremely tight budget. For a higher price, the Firstscope offers a 78-percent-greater light grasp and sturdier construction. (Celestron also told ASTRONOMY that they will be introducing the Firstscope tube assembly on an equatorial mounting in early 1990, so it might be possible to upgrade an altazimuth Firstscope into an equatorial.)

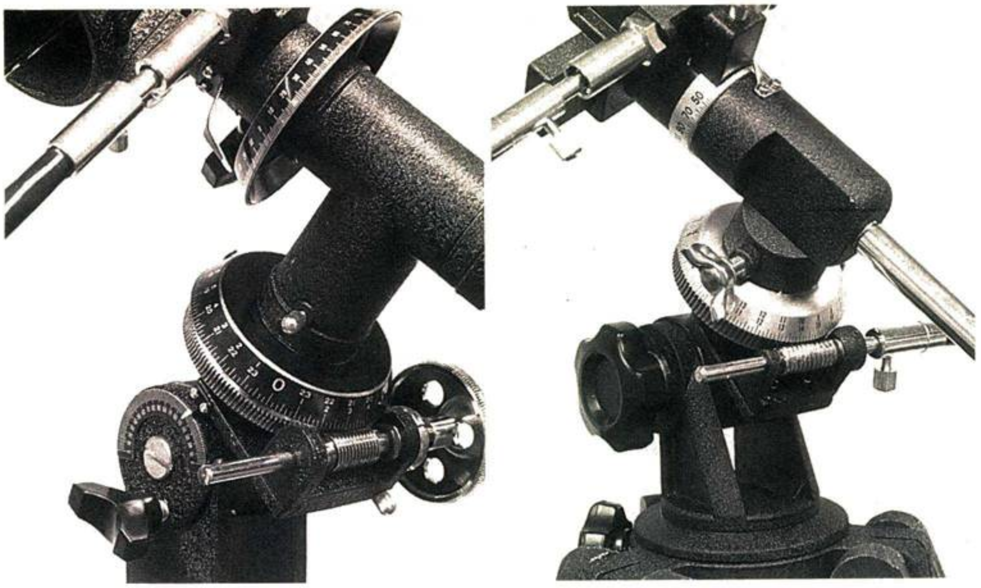
Equatorial Mountings = Capability

An equatorial mounting has one of its two axes parallel to Earth's rotation axis and points at the celestial pole. These mountings allow the viewer to follow a star or planet with a single slow motion. Like their altazimuth cousins, an equatorial has locking clamps and slow motions on both axes. It also has the capability to aim, adjust, and lock the polar axis so it points at the pole from any latitude. Anyone who intends more than casual or strictly low-magnification looks at the sky should get an equatorial mount. Also, they are essential for astrophotography. If you think that your interest in astronomy will grow, we strongly recommend an equatorial telescope.

An equatorial head is heavier than an altazimuth head. To gain good stability, an equatorial mounting needs a sturdier tripod than an altazimuth requires. We found that the equatorial tripods were indeed larger and beefier than the altazimuth tripods (except for the Firstscope, which had a heavier tripod to begin with). Both Unitrons had heavier mountings than the other scopes in their classes; the 60mm Unitron uses a mounting of a size that the other manufacturers use for their 80mm units. Naturally, greatly improved stability is the result.

The tripod legs on both Tascos, the Swift, the Meade, and the 80mm Jason telescopes fit into slots in the equatorial head (see photo at right). These slots make set up go a little faster; but if a wing nut should loosen unnoticed, the open-bottom slot could cause the leg to fall off suddenly if the telescope were picked up and moved. In addition to drop-out slots, the 60mm Tasco had the same weakness-producing vertical slits noted above in connection with the altazimuth Jason telescope.

Tripod leg tips on the 60mm Swift, the 80mm Jason, and the Tasco scopes were metal spikes sheathed in rubber. Used unsheathed on bare or grassy ground the spikes bit in firmly, but the rubber tips promoted a lot of wiggle when we tested these instruments on a concrete surface. The damping times with rubber tips typically ran 4 seconds — unacceptably long — while with the metal spikes unsheathed and embedded in grass, the vibrations lasted just 2 seconds. This is distracting but tolerable for most kinds of observing.

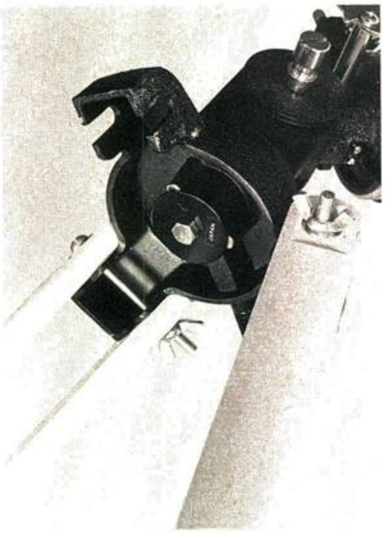


JUST TWO BASIC equatorial designs serve six different telescopes under five brand names (see text); model A (left) and model B (right).

We discovered some interesting similarities in the equatorial mountings: six telescopes from five companies share just two basic designs. (This is a useful point to keep in mind when comparing prices.) The mountings on the 60mm Meade, the 60mm Swift, and the 80mm Tasco equatorials were identical; the mounting on the 80mm Jason appeared to be a slightly scaled-up version of the same thing —we called this "model A." The 60mm Celestron and Tasco telescopes had equatorial heads that were identical to each other except for minor details — this type is referred to as "model B." (See photos above.)

The model A design (used by Swift, Meade, and the 80mm Tasco and Jason instruments) provides 180° of latitude adjustment; model B (60mm Celestron and Tasco) allows only 90°. However, the Celestron version of model B adds a small but useful feature: a thumbscrew pushes against a plate to lock the polar-altitude adjustment and to permit the minute changes necessary to acheive the precise polar alignment that astrophotography demands. The Unitrons allow precise adjustment by means of a machined turnbuckle.

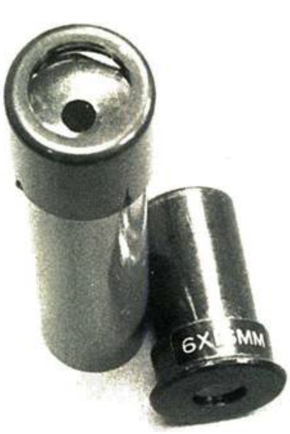
The slow-motion controls on models A and B turn smoothly with little backlash; the existing backlash occurs mainly in right ascension. However, the controls are placed such that they occasionally interfere with each other — for example, when the scope lies on the western side of the mounting and is aimed high in the east.



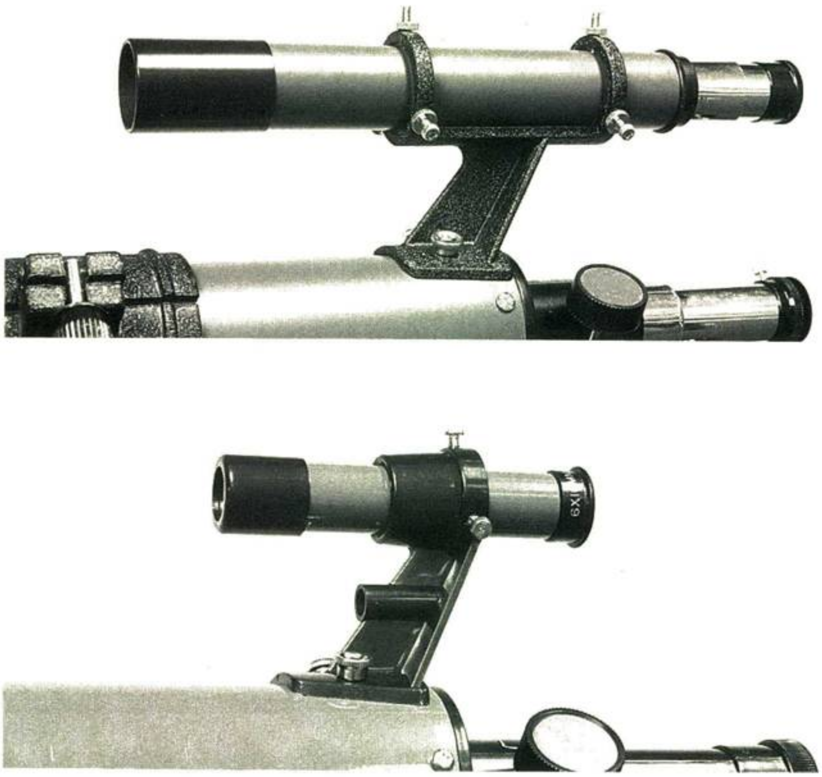
LEG SLOTS are found on many small refractors. They may shorten set-up time, but if the wing nuts loosen, the legs can fall off easily.

We found the model A slow-motion-control rods easier to use because they are longer and more flexible. The Unitron telescopes have short, rigid rods on their slow motions and one long, flexible rod on the right ascension drive; no interference ensues because the placements have been carefully designed to avoid it. Also, unlike model A, the Unitron right-ascension drive control can be shifted from one side of the axis to the other. (The same is true for the drive-control cable on model B.)

In general we found that the model A and B equatorial mountings performed with acceptable stability at



ACTUAL APERTURE for this finder is shown by the 5mm hole (left), despite the claim of 16mm on the eyepiece (right) and the big glass objective lens.



LONG-LASTING finder alignment comes from double-ring finder mounts with lock nuts on the screws. Cheaper finders have a single set of screws.

magnifications under 100x. (Typically, when these tripods are placed with their tips embedded in grass, vibration damps out in 2 to 3 seconds.) At higher powers, the instabilities of the tripod and head begin to dominate the performance and the result is an increasingly obvious and annoying shake in the image. We don't recommend using these mountings at any magnification over 100x.

To a certain degree, the mountings' problems lie in the relatively large amount of play evident when one takes the telescope tube by the objective end and shakes it slightly. For instance, we found up to 1° of play in the right-ascension gears. (This is the main source of the backlash found in many instruments.) Attachment screws for the gears allow some adjustment and the play can largely be eliminated, but none of the manuals tell the owner how to do this.

The two Unitron models provided very steady views and were gratifyingly solid, damping out vibrations in about 2 seconds. However, they displayed a certain amount of "chatter" when the right-ascension drive controls and slow motions were turned other than extremely slowly. This chatter was manifest as a vibration visible to the eye and was too great to be tolerated while viewing, even at lower powers.

The chatter concerned us. We contacted Unitron, who told us that the problem with the right-ascension controls was due to an imbalanced load. We rebalanced the scope, but the problem persisted. We found we could eliminate most of the right-ascension chatter by tightening the worm gear against the drive gear, but this made the worm very hard to turn. (The right-ascension and declination slow motions work by pushing a metal tab against a spring; these were unadjustable.) We felt that the chatter detracted from the pleasure of using the instrument.

Every one of the telescopes — altazimuth and equatorial — displayed a certain wobbliness in their focuser drawtubes when they were extended far enough to handle long focal length (low-power) eyepieces. None were in actual danger of falling out, but their looseness was sufficient to make us uneasy about aiming the scope by handling the tube next to the eyepiece, a natural action most telescope users would take without thinking.

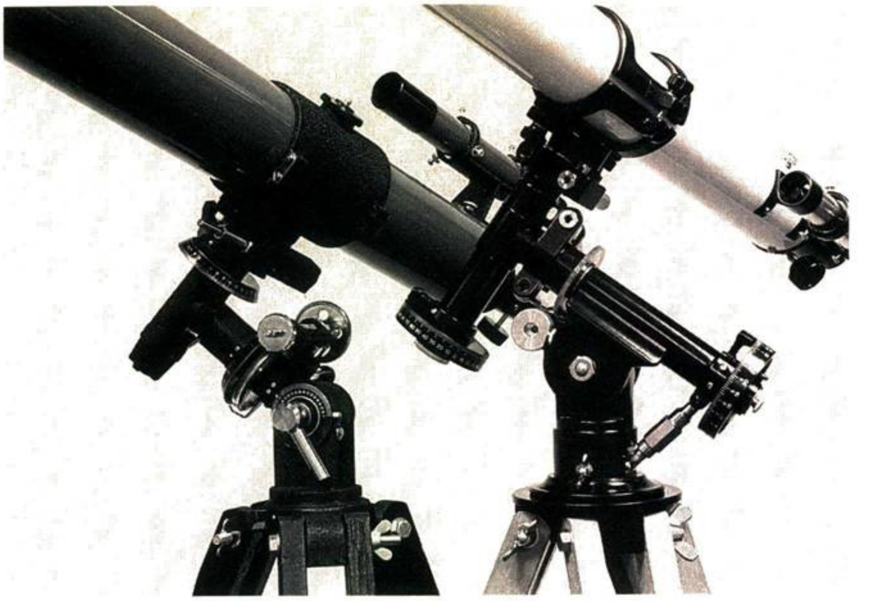
We were disappointed that no manufacturer gives the declination slow-motion knob a markedly different size or shape than the right ascension one — a simple feature found on every professional refractor built since about 1800. It would be a trivial addition, but it would certainly help out any observer fumbling in the dark.

Oh, Say Can You See?

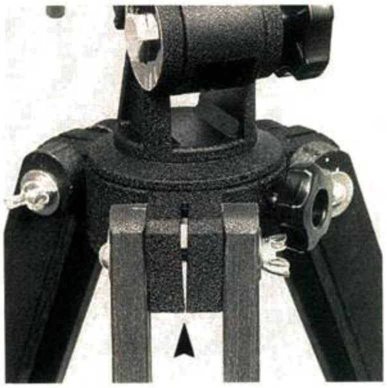
Objective lenses. The most important statement to be made about the small refractors we tested is that almost without exception we were unable to properly assess their optical performance while they were on their original mountings. The mountings were simply too shaky to permit us to examine a real or artificial star at 200x. (The Unitrons were the exception, but in the end we tested them the same way as the others to give a fair comparison.)

We constructed an artificial star and placed it 260 feet away; the telescope being tested was held in a jig. The star's image was less than 1 arcsecond across as viewed from the telescope. We viewed this star with each of the telescopes several times, using high-quality eyepieces and magnifications up to 200x — although 100x was usually enough to reveal the Airy disk. We rated the instruments on a scale of 1 to 5, with 5 scoring the highest.

A 5 means that the objective lens produces an image as good as a perfect achromat can form. It has a slight amount of chromatic aberration, but no significant deviation from a perfect figure. A 4 means that the image wasn't quite as perfect, but it was close to it. Such a telescope would give excellent service. A 3 means that we found a significant error of some kind: minor assembly errors (such as misalignment) or errors of figure (spherical aberration, zonal errors, excessive chromatic aberration, or *astigmatism). With such defects you* aren't getting what you paid for, but beginners wouldn't notice the errors until they had gained more experi-



FOR GREATER STABILITY and reduced vibration, Unitron puts its 60mm telescope (right) on a larger equatorial than Tasco's 80mm (left).



THESE SLITS on the 60mm Jason deform as you tighten the wing nut (note the V shape), preventing tightest assembly and greatest stability.

ence. We felt a 3 represented the lowest acceptable quality.

A 2 rating means that the telescope's defects have exceeded acceptable limits. A 1 means the instrument has gross assembly errors, severe astigmatism, "wedging" (which turns star images into little spectra), or zonal errors. No instrument with such a rating can give good views and should be avoided.

The summary chart (page 82) shows relatively little consistency among the models tested. In the samples we examined, we found excellent optics on hard-to-use mountings (the Meade 226) and bad optics on adequate mountings (the Swift 859R). The Swift 863 has both bad optics and mounting. The Unitrons were generally good on both accounts, though the 60mm model was noticeably poorer optically than the 3-inch.

To us, such wildly divergent scores point toward poor quality control both by the manufacturers in Japan and the importers here in the United States. We wondered how often the companies that supply these telescopes examine the finished products before they are shipped to customers. In any case, this result means that a buyer has no simple and reliable guarantee of getting a good instrument, no matter who makes it. You should always test the instrument you receive and return it immediately if its performance isn't satisfactory. (See "How to Star Test Your Telescope," April 1983.) Moreover, you should keep rejecting them until you get an instrument you like.

Eyepieces. The eyepieces that come with small refractors typically give poor views. With the exception of the orthoscopics provided with the Unitron telescopes and the Kellner and orthoscopic eyepieces provided with the two Celestrons, all of the eyepieces were candidates for early replacement. If you are considering buying one of these telescopes, it is important to budget an additional $75 to $100 to purchase a couple of high-quality eyepieces at the outset.

Finder scopes. A good finder scope is essential to a telescope. The best finder scopes come with a two-ring mounting and double sets of aiming screws; cheaper ones use a single ring with only one set of aiming screws. A 30mm aperture finder is minimum and a 50mm is preferable on an 80mm scope, even if this means buying it as an "extra."

Eight of the telescopes had adequate, if small, finders. However, all three 60mm altazimuth scopes, plus the 60mm equatorial Tasco, had "fake finders" — our term for a finder scope that has a simple (non-achromatic) objective lens with a 15mm to 25mm aperture and an opaque disk behind it with a hole only 5mm to 10mm in diameter. These are all but useless because they have constricted apertures — only 5mm to 10mm — so they can't be used to find faint objects. (The disk, essential for eliminating the chromatic aberration of the simple lens, can be seen clearly when you look into the finder from the objective side [see photo on page 84].)

You can't always trust what it says on the finder either: the finders on the Jason 307 and Celestron C60E claim to be 5x24, the Tasco 851 TR claims 6x16. All three are false: their real apertures are 8mm, 8mm, and 5mm, respectively. Two other scopes with "fake finders" were the Swift 863 and the Meade 226. (The Meade 226 was the only scope with a "fake finder" in a two-ring mounting.)

Caveat Emptor!

Many manufacturers appear to be loading small refractors with features that contribute little to the enjoyment of astronomy — even when they aren't of a downright shoddy nature. Erecting prisms, Moon filters, "fake finders," Barlow lenses, and zoom lenses fall into this category, together with eyepieces that give worthless high magnifications. These items have no place in a beginner's astronomical telescope outfit.

The first-time telescope buyer is much better served by a telescope that has one or two eyepieces of excellent quality than an array of mediocre to poor ones. More than anything else, small refractors need sturdy mountings. We can't overstress this. Newcomers to astronomy should walk out of the store, money safely in pocket, if they can't find an instrument that passes the stability test we mentioned at the beginning.

The table on page 82 lists retail list prices; the "street-price" from a dealer will be substantially less. It is worth shopping around for prices, but to let the decision be governed solely by price would be a mistake. Look for the lowest-priced telescope whose mounting meets your stability requirements and whose optical quality is acceptable. If you can't find one in your price range, you'll get more satisfaction from an excellent pair of 7x50 or 11x70 binoculars than a 60mm telescope on a wiggly mounting.

Whether or not it's the ideal "starter scope," the classic small refractor doesn't have to be a toy. But toylike telescopes will continue to dominate the market as long as buyers act on the assumption that the lowest price tag with the most "features" equals the best telescope. ☐

GENESIS OF A LEGEND

The revolutionary design of the Schmidt-Cassegrain telescope put big-scope power into the hands of the average observer.

by Alan Dyer

For the past twenty years, the 8-inch Schmidt-Cassegrain telescope has dominated the amateur telescope market. Although die-hard deep-sky observers may now opt for large-aperture Dobsonian reflectors and planetary observers may prefer apochromatic refractors, the Schmidt-Cassegrain is a more portable and versatile general-purpose telescope and is well-suited to photography. The SCT's combination of a mirror and a corrector lens provides a potentially ideal optical system with a relatively large aperture.

Generically, this half-reflector and half-refractor telescope is called a catadioptric system, or "Cat" for short. Since its introduction in the late 1960s, the Schmidt-Cassegrain has evolved from its primitive form into a bewildering variety of species, some adapted to specialized observing "niches." In fact, there are so many species of SCTs now prowling the telescope market that it's easy to get lost in the jungle of ads and hype. Confused by the difference between the LX-3 and LX-5? Should you get a Super Polaris or a Classic 8? You must know the relative strengths and weaknesses of the various models and your own needs and desires to be able to make an informed decision.

The Evolution of the Cat

The SCT is not a new design. Amateur telescope maker Bernhard Schmidt invented his wide-field, distortion-free astrocamera back in the 1930s. A decade later, the astronomers and engineers at Palomar Observatory first applied Schmidt's design to professional telescopes. Their Schmidt cameras, along with others built around the world, have surveyed the sky as never before.

The design variation that turned a Schmidt camera into a visual telescope was a familiar technique. The problem was that the complex corrector plate was very difficult to grind and test. Even today, only very advanced amateur telescope makers are able to pull it off.

In the 1960s Tom Johnson was one of those pioneering telescope makers. Lured by the almost perfect star images the Schmidt-Cassegrain could theoretically produce, Johnson built an 18.75-inch SCT. This prototype was the forerunner of all the Celestrons ever made. In 1964 Johnson renamed his electronics company Celestron Pacific and switched to making Schmidt-Cassegrain telescopes. They kept costs down by using a special vacuum-forming technique to manufacture the otherwise labor-intensive and costly corrector plate. This breakthrough meant Celestron could mass-produce SCTs.

PIONEERING THE 8-INCH Schmidt-Cassegrain telescope was Celestron, who introduced the C8 to the marketplace in 1970.

Celestron's first telescopes were aimed at college observatories and wealthy amateurs. In the late 1960s, large 22-, 16-, 12-, and 10-inch telescopes were Celestron's specialty. Because the market for big telescopes is limited, Celestron decided to enter the mass marketplace in 1970 with an 8-inch model, the C8. The retail price for the basic telescope without a tripod was $795. Considering that fully equipped 8-inch Newtonian reflectors were going for $600 back then, the C8 was a high-end product. But, attracted by its compact size and ease of use, many observers thought the new telescope was worth it.

The Competition Appears

With such an advantage over Newtonians and refractors, it was only a matter of time before another SCT appeared on the scene. In 1971 a company long known for its low-cost but highly respected Newtonian telescopes introduced a competing SCT. The company was Criterion and the telescope was called the Dynamax 8. The price was about $100 cheaper than the C8.

The Dynamax, however, proved to be little trouble for the fledgling Celestron. It was plagued by long delivery delays, quality-control problems, and a generally inferior design that featured a cardboard tube. Many dealers wouldn't carry it, and many amateurs wouldn't buy it. Surprisingly, this model survived on the market until early 1988, though restyled as the Bausch and Lomb 8001.

Serious competition for Celestron arrived in 1980, when Meade Instruments introduced their Model 2040 4-inch and Model 2080 8-inch Schmidt-Cassegrains. Meade began selling telescope accessories in the early 1970s. Like Criterion, they then made a name for themselves by selling good-quality Newtonians. Unlike Criterion, Meade was able to deliver a telescope that feature-for-feature and dollar-for-dollar competed very successfully with the Celestron models.

As of late 1989, Meade and Celestron each offer five models of 8-inch Schmidt-Cassegrain telescopes. Both

manufacturers produce two telescopes aimed at consumers with about $1,000 to $1,300 to spend. Meade markets the fork-mounted MTS and the standard 2080 models, and Celestron counters with the German equatorially mounted Super Polaris and the Classic 8 fork-mounted scope. In the mid-level price range, from about $1,400 to $1,700, Meade offers the LX-3 and LX-5 models and Celestron the Powerstar Model IV.

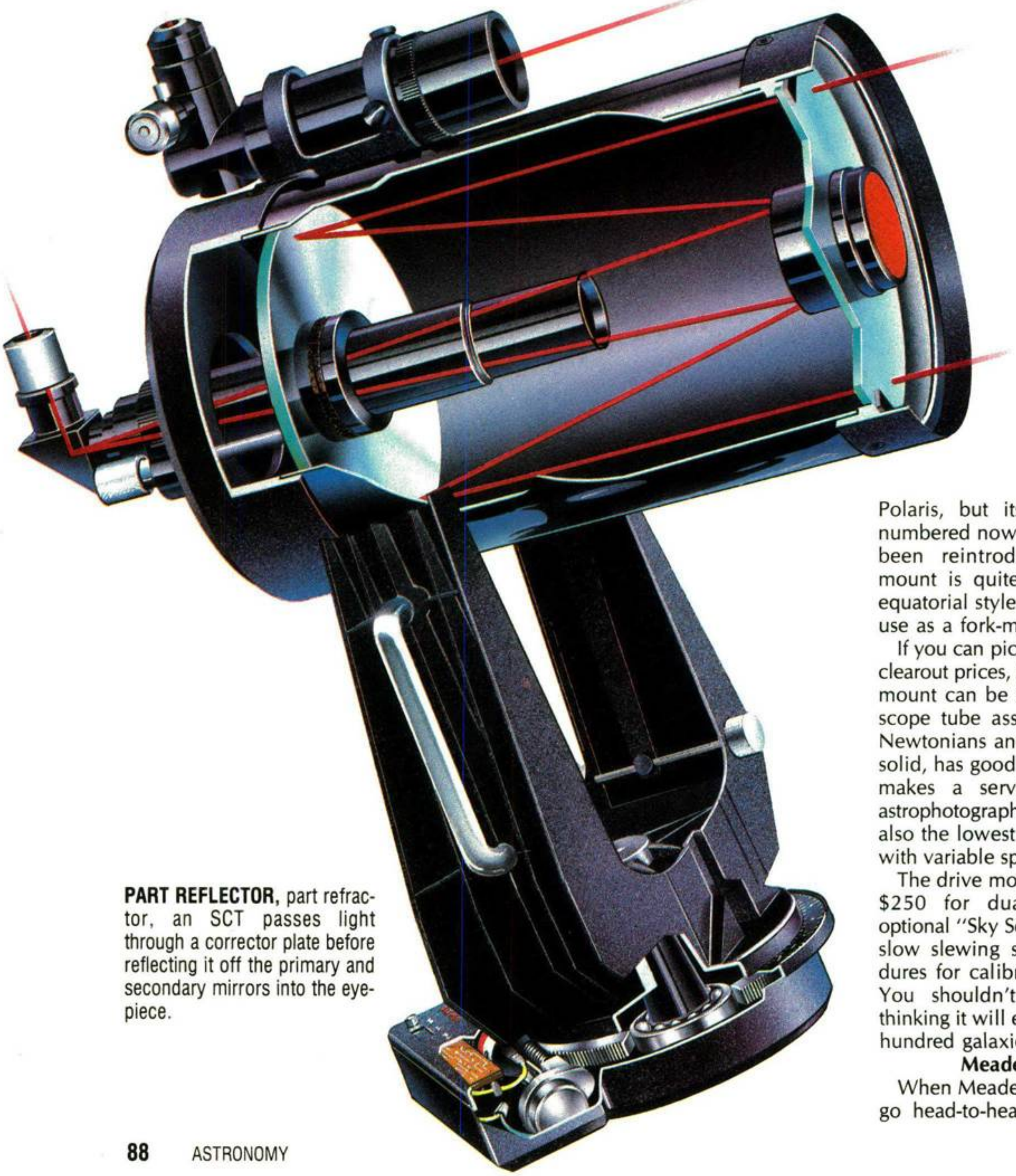
At the high end of the market with prices ranging from $2,000 up, there are two specialty scopes for astrophotographers, the Meade LX-6 and the Celestron Ultima 8. Celestron's Compustar, at $3,500, is in a league by itself, although you can get a Meade telescope with similar capabilities (without the slewing motors) by adding the Meade Computer Aided Telescope system to the LX-6. Each of the ten models have strengths and weaknesses that you'll need to know about to find the specific model that best meets your observing needs.

Both Meade and Celestron offer budget-priced models for prospective buyers interested in a basic SCT without a lot of frills. Each company has a version on a special low-cost mount, and now each has reintroduced their original SCTs on standard fork-mounts.

Celestron Super Polaris

Prior to 1984, your choice in 8-inch SCTs was simple: it was either a Meade 2080 or a Celestron C8. In September 1984 Celestron added the Super Polaris C8, a bottom-end model that sold for about $800. The idea was to offer an entry-level scope as an alternative to the increasingly expensive main models.

The tube assembly of the Super Polaris was (and is) the same as the other models, but the mount was different: a German equatorial design that for the first time introduced battery-operated DC pulse motors. Prior to this, all telescope drive motors had been AC synchronous units, which in North America ran off 60 Hz/120 volts. The optional Super Polaris motors ran directly off pen light batteries or a car battery with no need for any electronic inverters or drive correctors. It was a breakthrough, and the first strike in the battle between Meade and Celestron to outdo each other in the field of drive electronics.



PART REFLECTOR, part refractor, an SCT passes light through a corrector plate before reflecting it off the primary and secondary mirrors into the eyepiece.

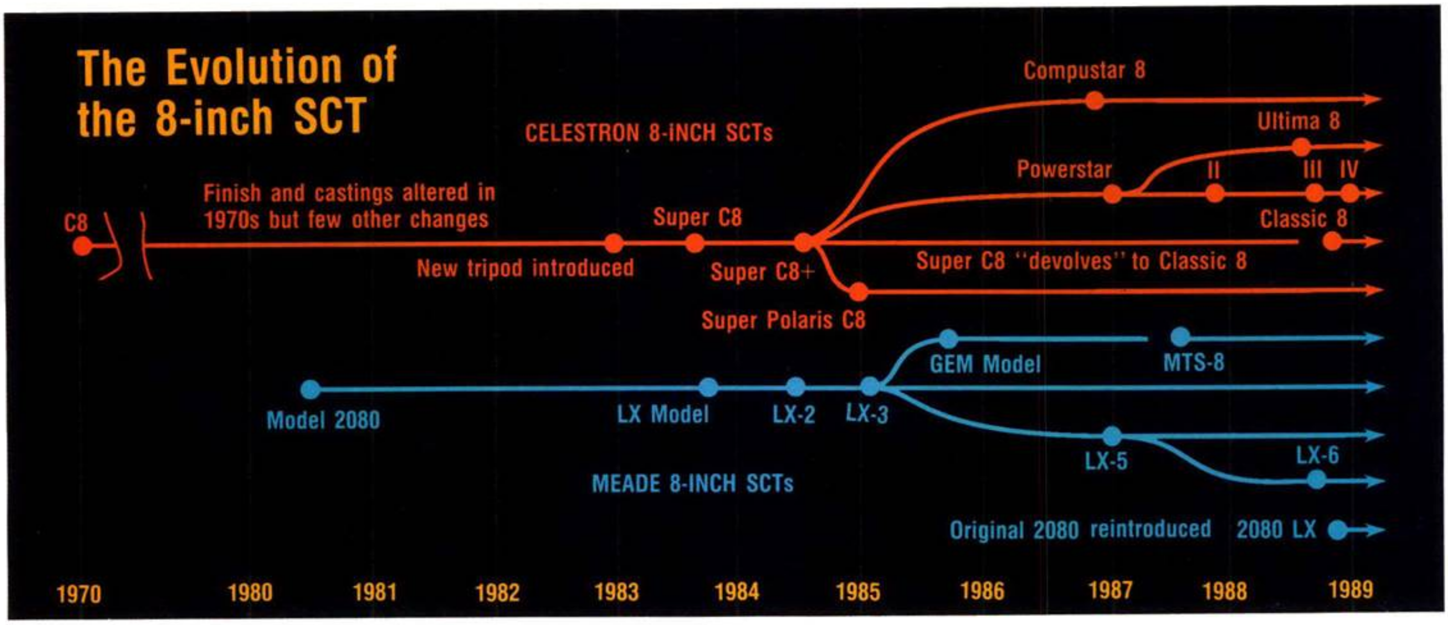
Celestron still offers the Super Polaris, but its days are probably numbered now that the Classic 8 has been reintroduced. Although the mount is quite sturdy, the German equatorial style isn't as convenient to use as a fork-mounted telescope.

If you can pick up a Super Polaris at clearout prices, it may be worth it. The mount can be adapted to other telescope tube assemblies, such as fast Newtonians and refractors. It is fairly solid, has good fine adjustments, and makes a serviceable platform for astrophotography. The Super Polaris is also the lowest priced SCT equipped with variable speed DC pulse motors.

The drive motors are extra and cost $250 for dual-axis control. The optional "Sky Sensor" computer has a slow slewing speed and the procedures for calibrating it are complex. You shouldn't buy the computer thinking it will effortlessly show you a hundred galaxies in an hour.

Meade MTS Series

When Meade needed something to go head-to-head against Celestron's


The Evolution of the 8-inch SCT

budget Super Polaris telescope, they brought out what they called the GEM series — German Equatorially Mounted SCTs. Like the Super Polaris models, the GEM scopes also had DC motors plus an optional computer that stored the positions of several hundred objects and sent pulses to the motors to drive the mount to that object. Unfortunately for Meade and Celestron, neither of their computers worked well, and at $500 they were contrary to the low-end market niche of the Super Polaris and GEM-mounted scopes.

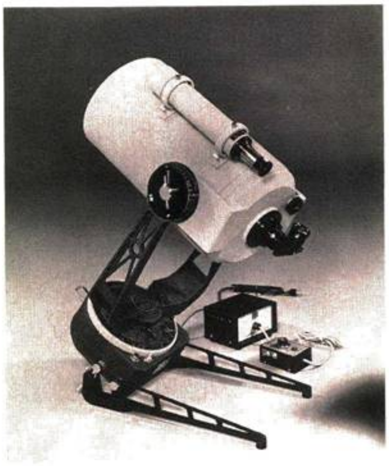
The final blow to the GEM series was the rising value of the yen. The GEMs used Japanese-made mounts; the price for these mounts increased to the point that Meade decided to discontinue the scopes. To replace the GEM series, Meade brought out a line of telescopes called the MTS, or Modular Telescope Series, in mid-1987. These were American-made, no-frills, fork-mounted Schmidt-Cassegrains with a base price of $1,000 to $1,300 with mount and drive, which could be upgraded with various options.

The MTS Series provides a fork-mounted telescope at a relatively low price. It can be purchased with a standard AC motor drive or with the fancier DC pulse motor drive used in the LX-3 model. There are several options available, making it easier to upgrade or retrofit than the standard Model 2080 or the Celestron Classic.

By the time you add all the extras, the price is similar to that of a standard LX-3. The pier mount is difficult to set up and polar align, which makes the scope inconvenient for astrophotography. The mount does not break down easily into smaller components for ease of transport — it's very awkward to detach the tube from the forks or the fork arms from the base.

Celestron Classic 8

In the last couple of years we've seen a flurry of "new" no-frills models. Celestron's answer to Meade's MTS scopes came in late 1988, when they introduced the Classic 8. It was the old C8 back again with the same features (or lack of them) as the original 1970s model: no electronics, no computers, no DC motors, no electric focusers, and no niceties like large finder scopes and 2-inch diagonals. It's a giant step backward in evolution — or is it? The proven wedge-and-tripod fork mount is as simple to set up and use as any other mount, and the low cost of Celestron's Classic makes it attractive.


THE FIRST COMPETITOR to the C8 was Criterion's Dynamax 8, but it couldn't compete with Meade and Celestron.

The Classic 8 performs well and at 1970's prices is a bargain. If you are content to live without luxury features, this could be all the telescope you need. With no electronic parts, there are fewer gadgets to malfunction and less bother in setting up.

Although the Classic 8 is good for general-purpose photography, the spur gear drive has periodic tracking errors that hamper prime-focus deep-sky photography. The AC motor requires an inverter ($100 to $200 extra) to run in the field off a battery. The 6x30 finder scope is inadequate for finding your way around the sky; an 8x50 is far better on an 8-inch telescope. Although you can add a declination motor, electric focuser, and digital circles, you can't upgrade a Classic to the functionality of a Powerstar.

Meade Model 2080

Meade quickly countered Celestron's Classic 8 with a "classic" model of their own. Earlier this year, they also reintroduced their first SCT to the market. Their original Model 2080 with AC motor and "long exposure" (LX) worm gear drive is available for $1,000, which is less than what the telescope sold for when it left the market in 1984. (However, the new 2080 tripod is much lighter than the Meade tripod included with the original 2080, which is still used on their more expensive telescopes.) Clearly aimed to compete with Celestron's Classic 8, the 2080 also undercuts Meade's own MTS-8, though the MTS-8 system gives you the option of adding the same quartz DC drive system featured on Meade's LX-3 model.

As with Celestron's Classic 8, the Model 2080 is easy to use. The LX

Feature Comparisons for Current 8-inch SCTs

	Celestron Super Polaris	Celestron Classic 8	Celestron Powerstar IV	Celestron Ultima 8	Celestron Compustar	Meade 2080	Meade MTS-8	Meade 2080 LX-3	Meade 2080 LX-5	Meade 2080 LX-6
FOCAL RATIO	f/10	f/10	f/10	f/10	f/10	f/10	f/10	f/10	f/10	f/6.3
STANDARD COATINGS										
Corrector	MgF_2	MgF_2	MgF_2	MgF_2	MgF_2	MgF_2	MgF_2	Multi	Multi	Multi
Mirrors	Enh. Alum.	Alum.	Enh. Alum.	Enh. Alum.	Enh. Alum.	Enh. Alum	Enh. Alum.	Enh. Alum	Enh. Alum.	Enh. Alum.
MOUNT	G.E.	Fork	Fork	HD Fork	Fork	Fork	Fork	Fork	Fork	Fork
DRIVE										
Gear Type	worm	spur	worm	worm	worm	worm	worm	worm	worm	worm
R.A. Motor Type	DC	AC	DC	DC	DC	AC	ACorDC	DC	DC	DC
Dec. Motor Incl.?	option	option	option	option	yes	option	option	option	option	option
ELECTRONICS										
Speed Override	2x/8x	no	2x/4x	2x/4x	2x/4x	no	2x	2x	2x/8x	2x/8x
North-South Switch	yes	no	yes	yes	yes	no	no	no	yes	yes
Dec. Motor Output	yes	no	yes	yes	yes	no	yes	yes	yes	yes
Elec. Focuser Output	no	no	yes	yes	yes	no	no	no	yes	yes
Reticle Output	no	no	yes	yes	yes	no	yes	yes	yes	yes
Digital Circles	option	option	option	option	yes	option	option	option	option	option
Computer	option	option	option	option	yes	option	no	option	option	option
AC Adapter Incl.?	no	N/A	yes	yes	yes	N/A	yes	yes	yes	yes
ACCESSORIES										
Finder Scope	6x30 RA	6x30 ST	8x50 RA	8x50 RA/ST	8x50 RA	6x30 ST	6x30 ST	8x50 RA	9x60 RA	9x60 RA
Star Diagonal	1.25″ prism	1.25″ prism	1.25″ prism	1.25″ prism	2″ mirror	1.25″ prism	1.25″ prism	1.25″ prism	2″ mirror	2″ mirror
Dew Cap	n/i	n/i	incl.	n/i	n/i	n/i	n/i	n/i	n/i	n/i
Camera Adaptors	n/i	n/i	incl.	incl.	n/i	n/i	n/i	n/i	n/i	n/i
Eyepieces	26mm Plossl	25mm Kellner	30mm Plossl 7mm Ortho	30mm Plossl 7mm Ortho	50mm Plossl	25mm Kellner	25mm Kellner	26mm Super Plossl	26mm Super Plossl	26mm Super Plossl
APPROX. PRICE incl. Wedge, Tripod, and Basic RA Drive	1,100	1,300	1,700	2,400	3,500	1,000	1,100	1,400	1,700	2,000

STANDARD COATINGS. MgF_2: Magnesium fluoride single-layer coating. Multicoated correctors and enhanced aluminum mirrors often available as options where not standard. *MOUNT. G.E.:* German equatorial, *Fork:* Fork mount, *HD Fork:* Heavy-duty fork. *DRIVE.* DC motors operate directly off batteries. AC motors require power inverter (separate accessory) to operate off battery in the field. *ELECTRONICS. Digital Circles:* Digital setting circles included or available as add-on option. (Digital circles can be retrofitted to most telescopes with accessory kits. Meade LX-6 has provisions for digital circle readouts in the hand controller.) *Computer:* Computer included or available as easy-to-attach option. (The Meade Computer Aided Telescope system can be added to most telescopes with add-on kit.) *ACCESSORIES. Finder Scope: RA,* Right-angle finder; *ST,* Straight-through type; *RA/ST,* can be used both ways. *APPROX. PRICE.* Prices are general market prices from major U.S. dealers as of mid-1989. These are heavily discounted below manufacturer's suggested retail price. Prices will vary. Local dealer prices may be higher. Manufacturers reserve the right to change specifications without notice.

gear system is the same one used in their upscale models, making this a good entry-level scope for prospective deep-sky photographers.

Unlike the MTS Series, the AC drive cannot be upgraded to a DC pulse motor version. It, too, requires an inverter for field operation. The tripod is light and lacks fine altitude and azimuth adjustments for precise polar aligning.

Meade Model LX-3

When it came out in 1985, the Model LX-3 put Meade ahead in the competition for the high-end market. The LX-3 had quartz oscillator controlled DC motors that could run off a variety of power sources, a plug-in control box, reticle output, an 8x50 illuminated finder, improved wedge adjustments, and other extras. Basic corrector coatings were standard, but otherwise the optics remained the same as the original Model 2080. The LX-3 was the vanguard of a new line of high-tech scopes featuring built-in drive controls instead of add-on black boxes.

The LX-3, however, is living on borrowed time. Meade planned to drop the scope when the LX-5 came out, but they reduced the LX-3's price and found there was still a big demand for it. If you want to buy one, check around: Many dealers don't offer a significant price difference between an LX-3 and LX-5 — for a few hundred dollars more you may want to opt for an LX-5 with its larger finder, 2-inch diagonal, and other features.

The LX-3 has the convenience of a hand controller and DC drive, which provide a good system for astrophotography at a lower cost than Celestron's Powerstar or the LX-5. It is also often available at sell-out prices.

The LX-3 lacks the choice of slow or fast scanning speeds, Southern Hemisphere motor reversing switch, electric focuser output, and other newer features found in the Powerstar and LX-5. It also has a lower resale value.

Celestron Powerstar IV

First introduced to compete with Meade's LX-3, Celestron's Powerstar models evolved out of their Super C8. This early 1980s model boasted a high-quality worm gear drive, a welcome feature that answered complaints from astrophotographers about the original Celestron spur gear drive.

The Powerstar's DC motors can run directly off batteries. Combine this feature with the excellent drive and the ease of polar alignment and balancing that a fork mount provides, and the Powerstar becomes a good starting telescope for the serious astrophotographer. The latest Powerstar, Model IV, also comes standard with many important accessories, such as a larger finder scope, better eyepieces, a dew cap, camera adaptors, and enhanced coatings.

Visual observers and photographers may not need the added drive-control features found on the Model IV, particularly at the extra cost. Plus, like most SCTs, the tripod is shaky for demanding astrophotography.

Meade Model LX-5

In May 1987 Meade brought out the LX-5, an improved version of the LX-3. Compared to the LX-3, the LX-5 has a better control panel with outlets for electric focus and declination motors, a north-south motor-reversing switch, 2x guiding and 8x scanning speeds, a 9x60 finder, and a 2-inch star diagonal as standard. All this goes for about $1,700, the original price for the LX-3.

The drive-control features on the LX-5 are excellent for photography and for slewing around at high power. The 2-inch star diagonal and the inclusion of outlets for add-on electric options are useful additions.

When fully outfitted, however, the electric gadgets tend to tangle the telescope in cables and wires, and the fork arms can collide with the cables and plugs. The fork mount and tripod are somewhat bouncy.

Meade Model LX-6

The big news from Meade in 1988 was their Model LX-6, an f/6.3 SCT with provisions for position encoders, digital setting circles, and their newly acquired Computer Aided Telescope computer. The faster focal ratio is better for photography but comes at the expense of a larger secondary mirror obstruction.

The LX-6 provides faster speed for deep-sky photography, which means you can take shorter exposures, and a wider field for deep-sky viewing. The built-in digital setting circles use software routines to make the readouts easy to calibrate.

The larger secondary mirror on the LX-6 degrades image contrast. The question is, will you notice the difference? For photography, certainly not. For visual observing, purists will say yes and others say no. It's an issue that may never be settled because visual observing is so subjective. The f/6.3 optical design Meade selected creates additional minor aberrations, such as astigmatism and coma. As with the LX-3 and LX-5, the tripod and mount are bouncy.

COMPETITIVE PRESSURES have forced SCT manufacturers to include many feature-laden models, such as Meade's 8-inch LX-6.

Celestron Ultima 8

Celestron's newest high-end model is their $2,400 Ultima 8. The optics are the same as in their other models, but the mount has been improved. The fork arms are beefed up to reduce vibration. As a result, this is not a lightweight instrument, but then no telescope designed expressly for astrophotography should be.

Deep-sky photographers and serious lunar and planetary observers will benefit most from the heavy-duty mount. The design facilitates attaching heavy cameras on the scope. The Ultima has a built-in rechargeable battery that keeps wires and cables to a convenient minimum.

Unfortunately, the Celestron tripod was not upgraded sufficiently and is still shaky, especially with this heavy scope on top of it. The drive is the same as in the Powerstar; the Ultima would have benefited from an even better drive and gearing system. The hand controller for better guided astrophotography is $100 extra. The f/10 speed is slow for photography of faint deep-sky objects, although a telecompressor effectively converts the scope into an f/5.

Celestron Compustar

For about $3,500, Celestron's Compustar does everything a computerized telescope is supposed to do: it comes with a database of thousands of objects and has fast slewing motors that allow it to zip around the sky.

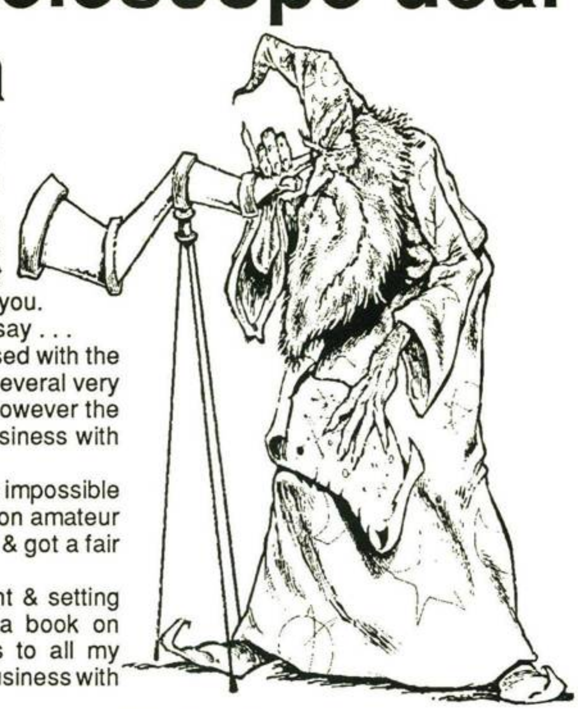
The Compstar's high-speed stepper motors and electronics are enclosed in a neat, unified package. Unlike an LX-6 equipped with the Computer Aided Telescope system, there are no tacked-on boxes, encoders, or cables left dangling.

The current model uses software that is three to four years old, though an updated version is likely soon. Be warned: with all the complexity, a lot more can go wrong; this is not a product for the novice. Like any high-tech product, you must take extra care in handling it. For the computer to work properly, you must also take extra steps to set it up. This is a scope best suited to permanent sites.

Despite their flaws, today's selection of Schmidt-Cassegrain telescopes presents a broad range of choice. Twenty years after the first 8-inch Schmidt-Cassegrain was introduced, the SCT has evolved into diverse forms. When you take inflation over the past several years into account, it's quite remarkable that you can once again buy Meade and Celestron telescopes at 1970s prices. Stiff competition and high-speed computerized manufacturing techniques have made this possible. Whether you go for a basic no-nonsense scope or a top-of-the-line computerized model, today's Schmidt-Cassegrain telescopes still represent an excellent value for your money. ☐

Alan Dyer is a Canadian science writer and amateur astronomer who has been involved in planetarium production, telescope sales, and astronomy education for fifteen years. The author would like to thank the people at Celestron and Meade for their comments on this article.

Stop looking for a telescope deal . . . and look for a telescope dealer!



A low price on the wrong scope is *not* a good deal. Most mail order stores can give you a low price, but are lost when it comes to giving you advice – the unbiased and honest advice you need to help you make the *right* decisions about what scope or accessories really make the most sense for you. We *can* give you that advice. Just listen to what our customers have to say . . .

"Recently I purchased a telescope from Astronomics & I am very pleased with the delivery, price, & especially the customer service I received. I received several very low quotes from NY/NJ camera shops, notably F____ and A_______; however the "tech-reps" I spoke to were so rude & abrupt that I decided that any business with these retailers would be bad business for me.

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"After receiving my telescope I had some questions about the mount & setting circles. When I called the manufacturer, they recommended I buy a book on astronomy – when I called Astronomics I received detailed answers to all my questions. So thanks for your help. You can be sure I will be doing all my business with you from now on. A satisfied customer . . ."

Another customer wrote, "Thank you for your help in assisting with my 8" SCT purchase. I appreciate the time, patience, and thoughtfulness of your answers to my questions. I'm sure I spent at least 30 min. with you between my two phone calls! It's a pleasure to do business with someone who shows as much knowledge and interest as you."

And still another wrote, "I want to thank your representative for the time he took to answer all my questions . . . I am not purchasing this telescope from you just because of the lowest price, but because of the service your company has to offer."

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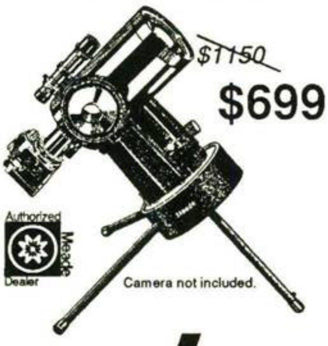

Camera not included.

~~$1150~~

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The Ghostly Glow of Gaseous Nebulae

You'll need to use a variety of observing tricks and filters to glimpse these extremely faint objects.

by David Higgins

As chilly nights and falling leaves lead us down the road to winter, make sure you get outdoors to see the winter Milky Way, which is visible in the early morning hours. This magnificent glowing band of light contains some of the most spectacular objects in the sky; however most of these objects are challenging targets for backyard telescopes because of their low surface brightnesses. This is especially true of a handful of softly glowing nebulae — winter's ghostly clouds of gas.

One of the most complex and beautiful winter emission nebulae is the **Rosette Nebula** in Monoceros (NGC 2237-9). Measuring 80′ by 60′, the Rosette Nebula is faintly visible as a soft glow in large binoculars or wide-field telescopes. A wreath-shaped complex of nebulous light, the Rosette contains a distinctive, dark "hole" in its center. Embedded within the nebula is the bright open star cluster NGC 2244, faintly visible to the naked eye from a dark sky. The cluster spans 40′ and is rectangular. The bright stars in NGC 2244 are very hot, and their ultraviolet light causes the nebula to shine. A few arcminutes west of NGC 2244 you'll see NGC 2239, a clump of stars associated with the Rosette nebulosity.

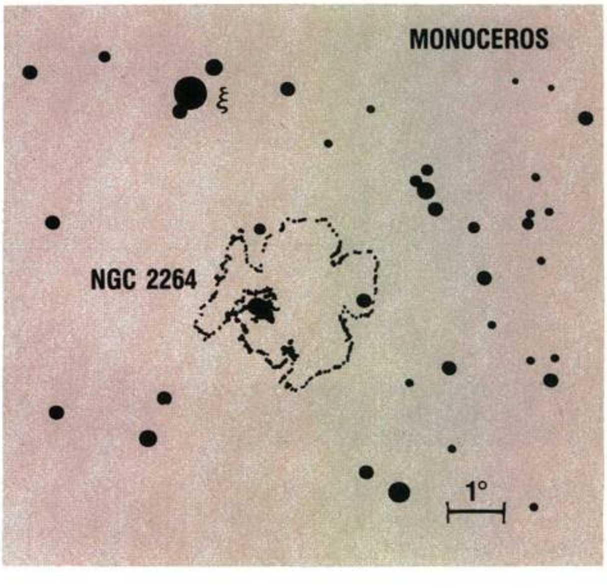
Finding the location of the Rosette Nebula is easy, but viewing the nebula is difficult under anything less than a dark sky. To find it, start by locating Epsilon (ε) Monocerotis, a 4th-magnitude star some 7° southeast of Betelgeuse. From this star, move 2° east-northeast, and you'll come upon the star cluster NGC 2244. This group appears as a splash of bright, blue-white stars in finder scopes. The brightest star in NGC 2244 is the magnitude 5.9 yellow giant 12 Monocerotis, probably a foreground star.

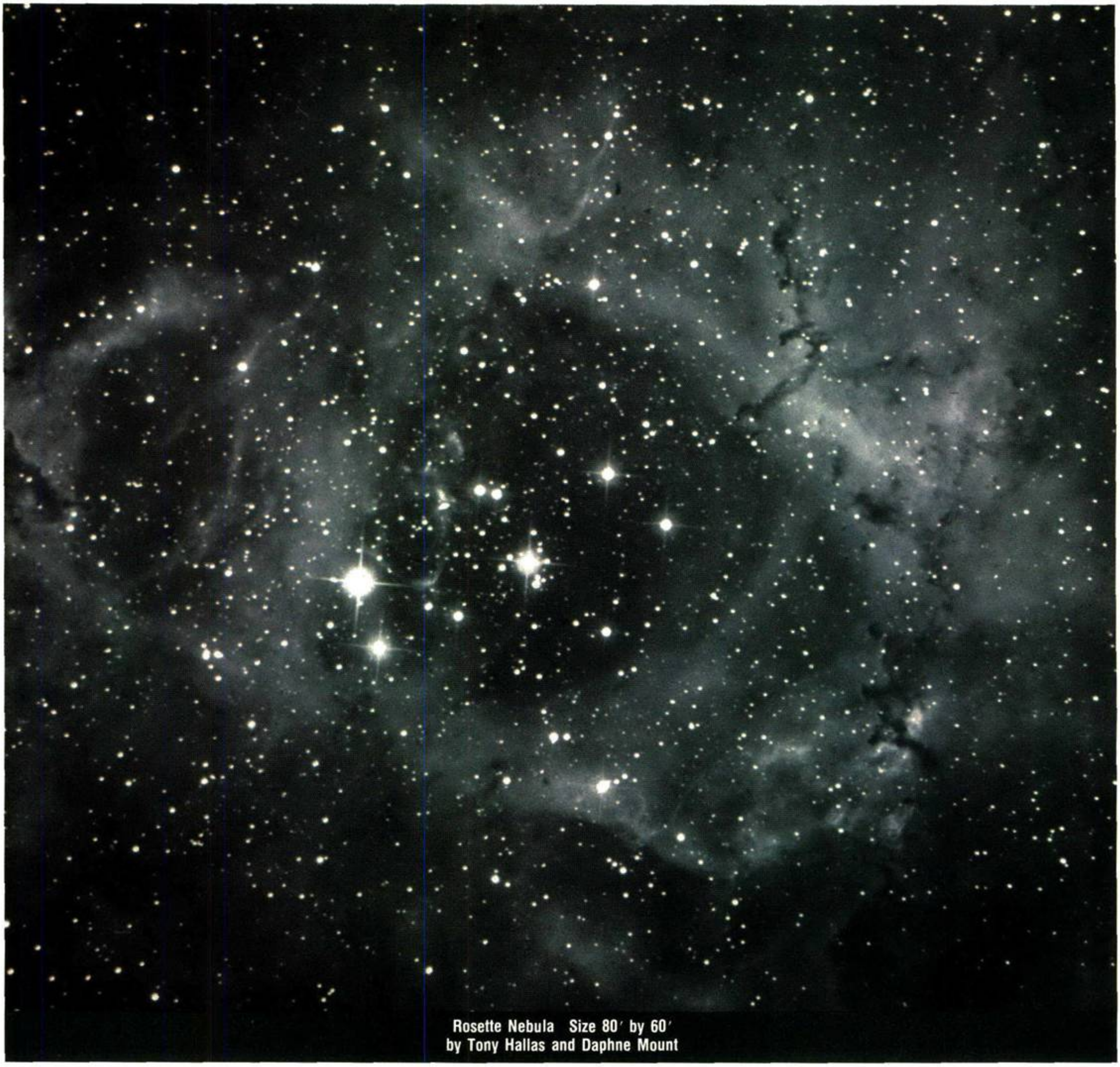
Seeing the Rosette nebulosity is somewhat trickier than locating the nebula. The northern portion, NGC 2246, is the brightest part and shows the most detail. NGC 2246's edges are well defined and easily visible, making this part of the Rosette detailed in a 6-inch or 8-inch scope. In larger telescopes dark nebulae are visible at high powers, forming chains and tunnels of dark nebulosity throughout the glowing bright nebulosity.

Low surface brightness nebulae like the Rosette are difficult objects to observe. However, several observing techniques can make them much easier to spot. First, take along a black cloth hood to cover your head and the viewing end of the telescope. By doing this, you'll eliminate scattered light from interfering with your view. Also, use a low-power eyepiece that gives you a wide field of view. Make sure you let your eyes dark adapt for

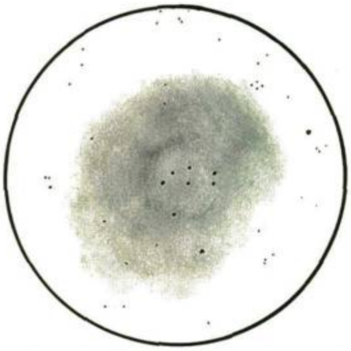
NGC 2264 Size 60′ by 30′
by Jack Newton

ELUSIVE NGC 2264 surrounds the bright star S Monocerotis, at right in the photo. The ruddy nebulosity at left outlines a dark cloud of dust dubbed the Cone Nebula.

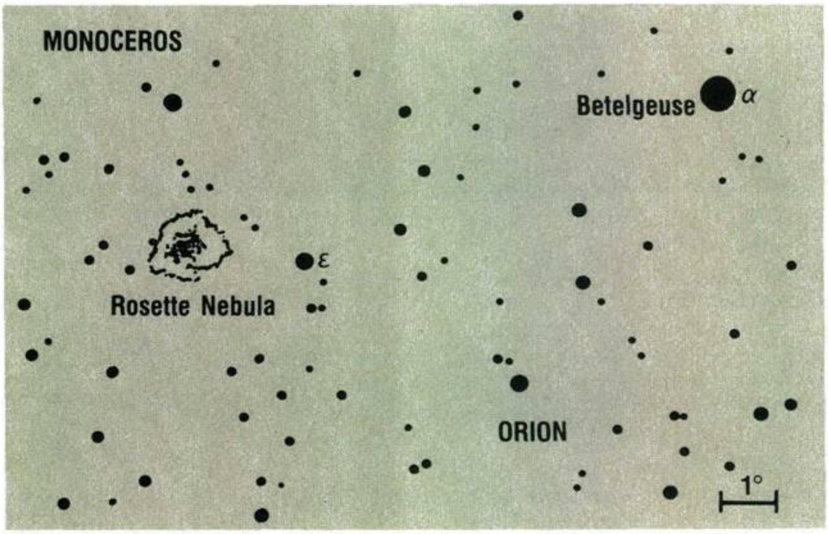




Rosette Nebula Size 80′ by 60′
by Tony Hallas and Daphne Mount



17.5-inch f/4.5 Reflector at 71x
Sketch by David J. Eicher



MONOCEROS
Betelgeuse
α
ε
Rosette Nebula
ORION
1°

FILAMENTS OF GLOWING GAS make up the Rosette Nebula in Monoceros.

half an hour or so in total darkness before attempting to spot faint details. Finally, use a nebular filter like the Ultra High Contrast (UHC) filter. This cuts out light pollution and lets only the light from the nebula itself into the telescope.

Challenging Nebulae of the Winter Sky

Object	R.A. (2000.0) Dec.		Size	Tirion	Uranometria
IC 410	5h22.6m	+33°31′	40′ by 30′	5	I: 97
NGC 1931	5h31.4m	+34°15′	3′ by 3′	5	I: 97
NGC 2237-9	6h32.3m	+05°03′	80′ by 60′	11, 12	I: 227
NGC 2264	6h40.9m	+09°54′	60′ by 30′	11, 12	I: 182

Object: Designation in NGC or IC catalog. **R.A. and Dec.:** Right ascension and declination in eqinox 2000.0. **Size:** Diameter of nebula in arcminutes. **Tirion:** Chart on which objects appears in *Sky Atlas 2000.0* by Wil Tirion. **Uranometria:** Chart on which object appears in *Uranometria 2000.0* by Wil Tirion, Barry Rappaport, and George Lovi.

After carefully viewing the Rosette, move your scope 4.5° north and 2° east and you'll find another complex of nebulosity and associated stars, designated **NGC 2264**. The star cluster contains 120 stars and measures some 20′ in diameter. Because of its distinctive shape, this object is sometimes called the Christmas Tree Cluster. Large areas of faint nebulosity surround the cluster and cover an area four times that of the Full Moon. On dark nights observers with 10 inch or larger instruments can spot this softly glowing nebula as a large, hazy patch of light.

The most famous object associated with this complex of nebulosity is the Cone Nebula. Although it is a dark nebula set against a very low surface brightness strip of bright nebulosity, the Cone can be glimpsed with small telescopes on extremely dark nights. A UHC filter, averted vision (glancing to the side of the field to use your eye's faint light receptors), and a black cloth hood thrown over your head help in spotting this tough object.

NGC 1931 in the constellation Auriga is a challenging target for scopes in the 6-inch or 8-inch range. Lying a little over a degree west of the open cluster M36, this nebula measures 3′ by 3′ and glows at about 11th magnitude. Contrary to the nebula's published dimensions, large telescope views show this object as slightly elongated east-west. At high magnifications this elongation suggests a large galaxy with a very bright nucleus.

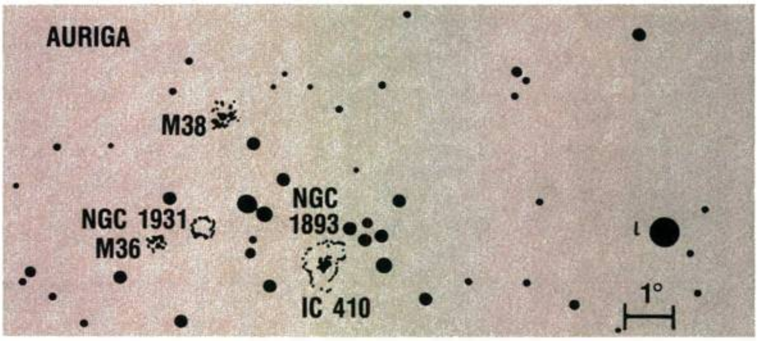
Another cluster/nebula combination in Auriga is IC 410. A faint, challenging cloud of nebulous light, IC 410 surrounds the bright star cluster NGC 1893. Locate the cluster first by sweeping 2° southwest of the bright star Phi Aurigae. NGC 1893 is a sparse cluster containing some twenty stars spread over 12′.

With averted vision on a dark night, you'll see some of the IC 410 nebulosity with a 6-inch scope. Because it is faint and measures roughly 40′ across, IC 410 has a low surface brightness. Consequently, low-power views are the most satisfying. On dark nights 6-inch telescopes show IC 410 as a faint glow with two bright areas aligned north-south; the southern section appears brightest. A large telescope in the 16-inch class reveals that the nebula's southern edge is mottled with dark areas that are speckled across faintly luminous patches.

Enjoy hunting these challenging nebulae this autumn and winter. As the chill pulls at you to go inside, you'll get a great feeling from knowing that these associated nebulae and star clusters are stellar nurseries lodged in the Galaxy's arms. By observing these objects, you're peeking into a region where amazing forces turn old stars into new ones. For me, observing in the cold air is inspiring. After all, the universe shares its secrets with anyone who is willing to approach it. ☐

David Higgins is central coordinator of the National Deep Sky Observers Society.

IC 410 Size 40′ by 30′
by Mace Hooley



CLUSTER AND NEBULA mingle in the case of NGC 1893 and IC 410 in Auriga.

TINY NGC 1931 is visible at high power as a nebulous spot only 2° northeast of IC 410.

NGC 1931 Size 3′ by 3′
by Martin C. Germano

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M83 in Hydra
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- **NGC 4565 in Coma Berenices**
- **The Helical Nebula**
- **The Trifid Nebula**
- **NGC 253 in Sculptor**
- **The Crab Nebula**
- **The Eagle Nebula**
- **The Pinwheel Galaxy**
- **The Bubble Nebula**

DEEP-SKY PHOTOGRAPHY FROM JACK NEWTON

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- **The Pleiades Star Cluster**
- **The Pelican Nebula**
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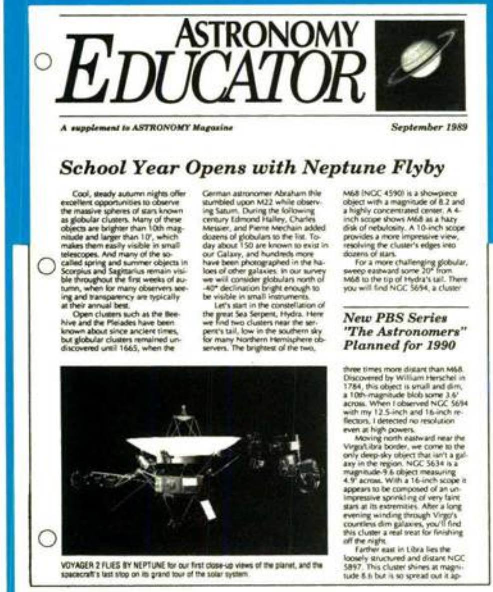

ASTRONOMY EDUCATOR

A supplement to ASTRONOMY Magazine

September 1989

School Year Opens with Neptune Flyby

Cool, steady autumn nights offer excellent opportunities to observe the massive spheres of stars known as globular clusters. Many of these objects are brighter than 10th magnitude and larger than 10', which makes them easily visible in small telescopes. And many of the so-called spring and summer objects in Scorpius and Sagittarius remain visible throughout the first weeks of autumn, when for many observers seeing and transparency are typically at their annual best.

Open clusters such as the Beehive and the Pleiades have been known about since ancient times, but globular clusters remained undiscovered until 1665, when the German astronomer Abraham Ihle stumbled upon M22 while observing Saturn. During the following century Edmond Halley, Charles Messier, and Pierre Mechain added dozens of globulars to the list. Today about 150 are known to exist in our Galaxy, and hundreds more have been photographed in the haloes of other galaxies. In our survey we will consider globulars north of -40° declination bright enough to be visible in small instruments.

Let's start in the constellation of the great Sea Serpent, Hydra. Here we find two clusters near the serpent's tail, low in the southern sky for many Northern Hemisphere observers. The brightest of the two, M68 (NGC 4590) is a showpiece object with a magnitude of 8.2 and a highly concentrated center. A 4-inch scope shows M68 as a hazy disk of nebulosity. A 10-inch scope provides a more impressive view, resolving the cluster's edges into dozens of stars.

For a more challenging globular, sweep eastward some 20° from M68 to the tip of Hydra's tail. There you will find NGC 5694, a cluster three times more distant than M68. Discovered by William Herschel in 1784, this object is small and dim, a 10th-magnitude blob some 3.6' across. When I observed NGC 5694 with my 12.5-inch and 16-inch reflectors, I detected no resolution even at high powers.

Moving north eastward near the Virgo/Libra border, we come to the only deep-sky object that isn't a galaxy in the region. NGC 5634 is a magnitude-9.6 object measuring 4.9' across. With a 16-inch scope it appears to be composed of an unimpressive sprinkling of very faint stars at its extremities. After a long evening winding through Virgo's countless dim galaxies, you'll find this cluster a real treat for finishing off the night.

Farther east in Libra lies the loosely structured and distant NGC 5897. This cluster shines at magnitude 8.6 but is so spread out it ap-

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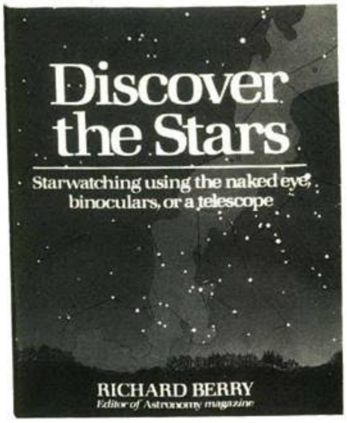

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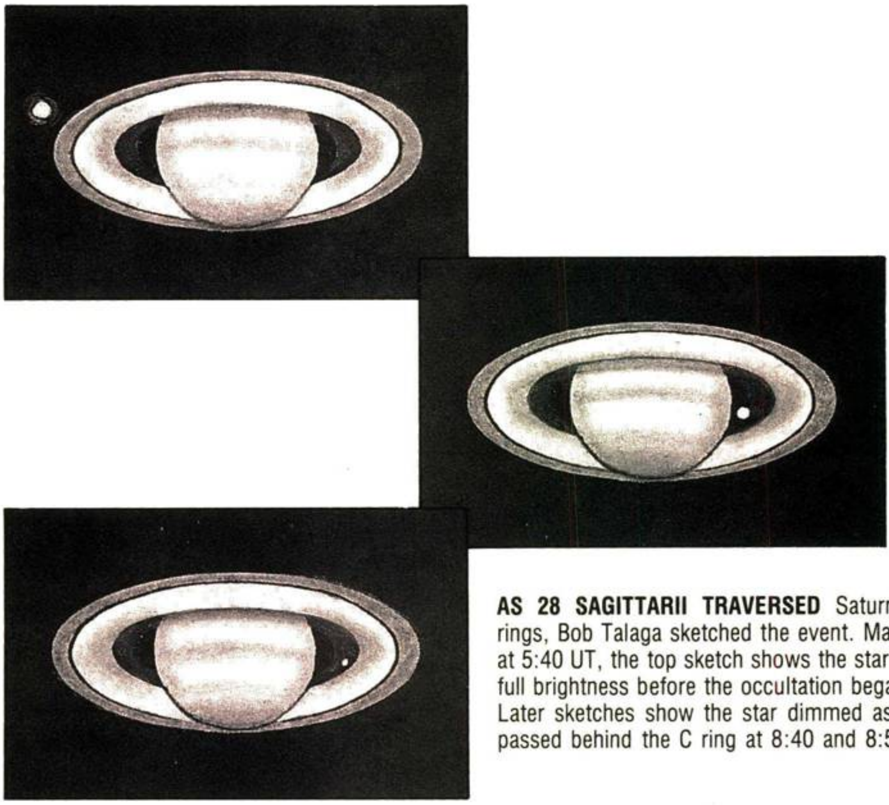
FIRST LOOK AT THE SATURN OCCULTATION

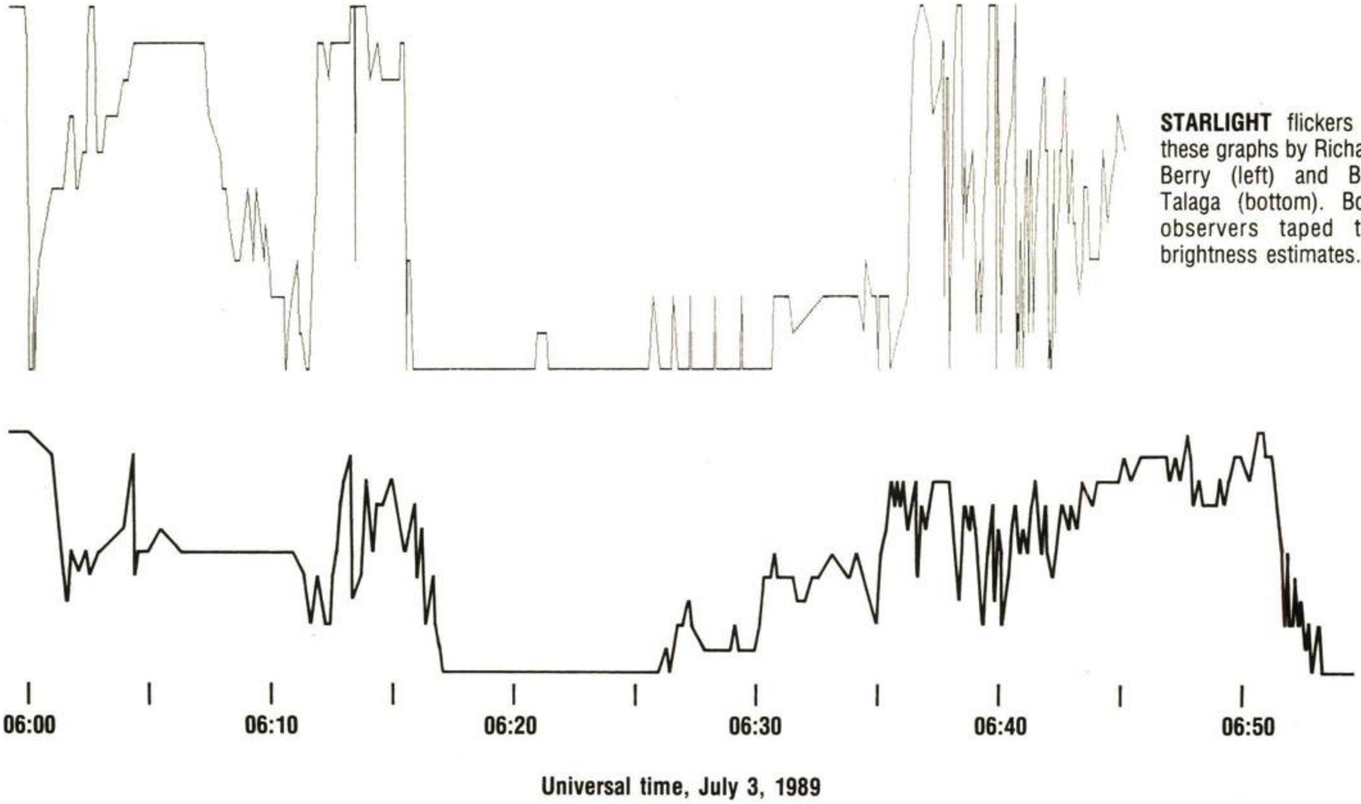
During the early morning of July 3, 1989, Saturn and its intricate ring system passed in front of the 6th-magnitude star 28 Sagittarii. The event was observed by ASTRONOMY readers around the world. In this Reader Reports we bring you reports ASTRONOMY received the week after the occultation.

The Southwest was the best region in the United States for observing the occultation. Observers there were able to see the occultation from the beginning to the end — a span of nearly four hours. Bob Talaga observed the occultation from Tucson, Arizona, with a 6-inch f/12 apochromatic refractor. "Data was acquired from dictating visual estimates into a cassette tape recorder along with WWV signals. Each point on the graph I plotted corresponds to one estimate of the star's brightness." Talaga also made sketches of the star's appearance during the event.

At New River, Arizona, Lloyd Horton and Steve Fetters observed the occultation with a 12-inch f/16 Cassegrain at 140x. "This is the first occultation we ever observed," said Fetters, "and if we ever get another chance at this, we'll know better what to do. We had our recorder too close to the WWV receiver



AS 28 SAGITTARII TRAVERSED Saturn's rings, Bob Talaga sketched the event. Made at 5:40 UT, the top sketch shows the star at full brightness before the occultation began. Later sketches show the star dimmed as it passed behind the C ring at 8:40 and 8:50.



STARLIGHT flickers in these graphs by Richard Berry (left) and Bob Talaga (bottom). Both observers taped the brightness estimates.

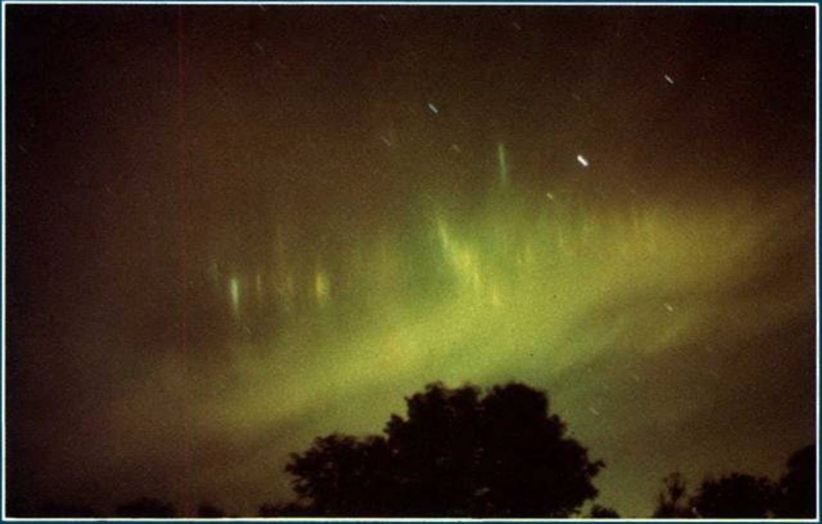
GIANT SOLAR PROMINENCE ERUPTS

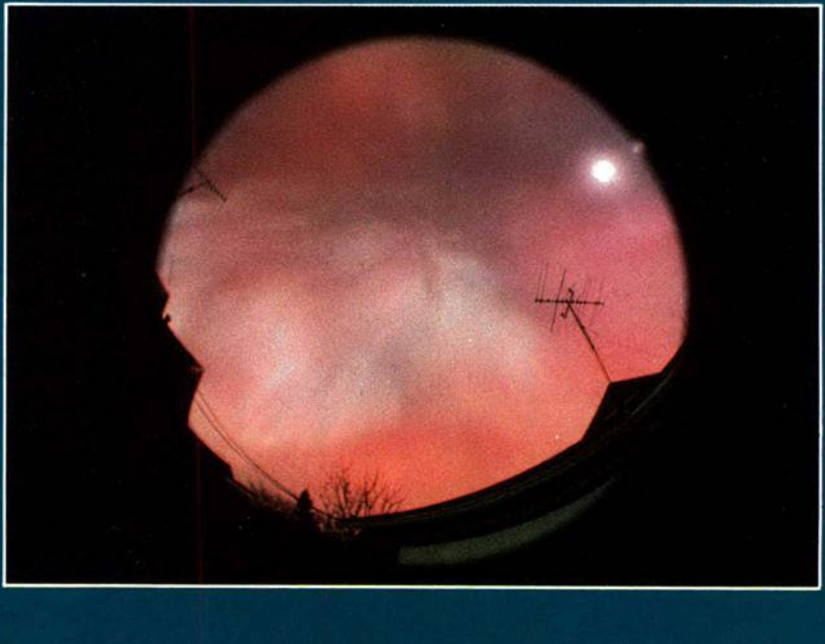
On May 22, 1989, an enormous eruptive prominence towered some 260,000 miles above the Sun's chromosphere. Franz Klauser's photo of the event (opposite page) made from Borg, Schulring, Austria, nets this month's $100 "Best Astrophoto" award. Klauser used an 80mm f/11.4 Vixen refractor with a "Baader Protuberanzenansatz" prominence viewer, Tech Pan film, and a 1/60-second exposure.

Earth's atmosphere intercepted some of the particles produced by this and other solar activity, resulting in spectacular aurorae. Five days after Klauser recorded the giant prominence, Chicagoan Roman Sobus captured a wild display of aurora consisting of arcs, rays, and sheets of greenish light (bottom). Sobus used a 50mm f/4 lens, Ektachrome 400 film, and a 4-minute exposure. From Utica, New York, John Ossowski recorded an aurora on March 13, 1989, with a fisheye lens, Kodak 400 ISO film, and a 20-second exposure (below).

Focusing on other parts of the solar system, John L. Underwood of Arlington, Virginia, photographed Pluto on several successive nights last May. "I located and observed Pluto right away with the finder chart in your May issue," said Underwood. His photos show the distant planet (arrow) on May 3 (top left) and May 7 (left) and were made with a 14-inch f/6 SCT, Konica SRV 3200 film, and 20-minute exposures.

Events in the solar system last spring didn't completely overshadow the starry background, however. From Riverside, California, Chester Roistacher made a distinctive portrait of the Big Dipper as it rose above the Sierra Nevada range (below left). Roistacher used a 50mm lens, 3200 speed film, and a 10-second exposure.





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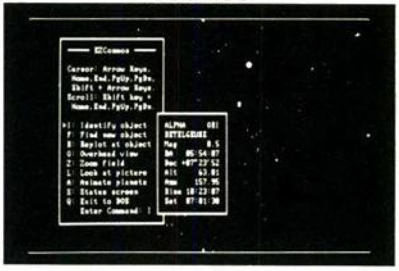

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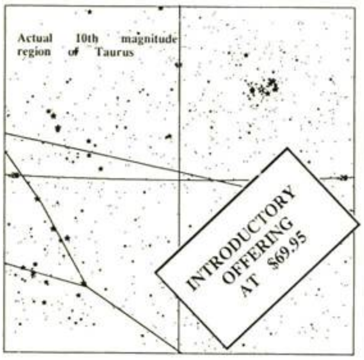

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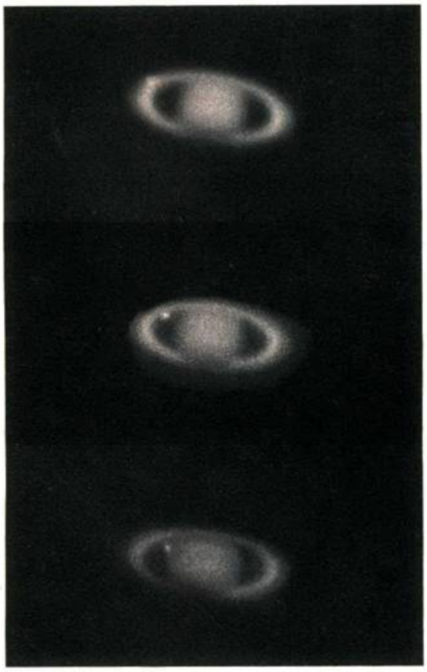

A 'BLIP' OF LIGHT in the rings marks the position of 28 Sagittarii. Robert Walton used a C11 and eyepiece projection.

and too far from us, so it was hard to hear our voices." Nonetheless, their tape recorder worked well enough that they have a permanent record of their observations.

Fetters noted that poor seeing made it difficult for them to tell how bright the star was. "The seeing was so bad that the rings actually merged with the planet at times." When 28 Sagittarii reappeared from behind the disk of Saturn, the observers exclaimed, "There it is! No fade in, it just blinked on." A minute later they noted that it faded and came back again.

Along the East Coast of the United States, Saturn was too low to observe when the star reemerged from behind the planet. Frank and Valerie Zaccardi, however, observed the first half of the occultation from Manville, New Jersey, with an 8-inch SCT and made visual estimates of the star's brightness while battling the buildup of dew on the telescope's corrector plate. "The progression of the event proceeded very much as detailed in ASTRONOMY, except for unexpected rapid and deep fluctuations as the star traversed the C ring," wrote the Zaccardis. "Four distinct on-off blinks were observed at 2:35, 2:36, 2:37, and 2:41 a.m. EDT. Unfortunately, we did not have access to precise time measuring equipment, so all the times we recorded are accurate only to the nearest minute."

In the Midwest, Robert Walton photographed the star in Saturn's rings. He used eyepiece projection at f/55 with a C11 telescope and hypered Tech Pan film from his home in Joplin, Missouri. "The seeing was good but the transparency was poor," noted Walton. The pictures Walton sent ASTRONOMY show 28 Sagittarii in the A ring, in the C ring, and approaching close to the planet.

From Wichita, Kansas, Jose Olivarez commented, "It was a wonderful experience for me to observe this exciting occultation under excellent seeing conditions. I felt that I was observing Saturn in three dimensions as the light of 28 Sagittarii sliced through the rings and Saturn's limb." Using 8-inch and 10-inch f/7 reflectors, Olivarez noted five dimmings in ring A and that the star was not visible while it was behind the brightest parts of ring B. "The star went through a series of eleven dimmings while it was

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behind the inner quarter of Ring B and the first third or quarter of ring C," wrote Olivarez.

When it reached Saturn, the star flashed as it went behind the globe of the planet. "The star flashed on and off six or seven times before it finally disappeared. This observation was made with the 10-inch reflector at 254x in excellent seeing." The star also flickered upon reappearance. "It first appeared as a lump on the limb of Saturn and was undergoing flashes so it would appear and disappear in succession. I counted eight definite flashes; however, there may have been as many as ten flashes."

From his backyard in Cedar Grove, Wisconsin, Richard Berry viewed the occultation with a 10-inch f/6 reflector. "As many others did, I recorded brightness estimates and comments about the occultation on tape," said Berry. "During the first half of the event, I made some 240 estimates on an arbitrary 0-to-10 scale of brightness.

"The graph I plotted from the taped observations showed that each ring has its own characteristics," said Berry. "The A ring has opaque edges and a fairly transparent center, and the star's brightness changed slowly in the A ring, with just a few sudden changes. In Cassini's division, I saw one a sudden and very deep dropout that lasted a second or two and several shallow dropouts. The outer parts of the B ring were largely opaque, but the inner region has gaps where the star's light could shine through.

"The real action started when the star entered the C ring," said Berry. "The star flickered almost constantly, bouncing from full brightness to invisibility in seconds. It was a tremendous thrill to see so much fine detail."

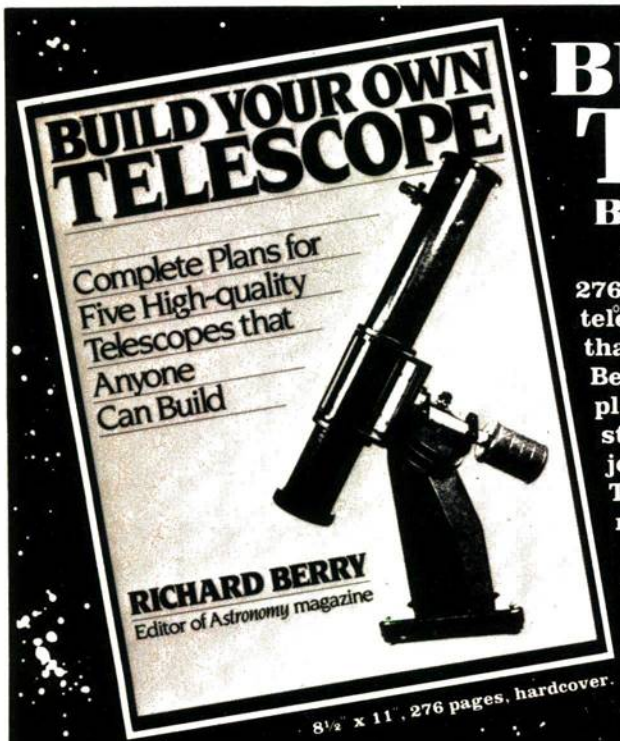
On the other side of the globe, Australian observer Peter Conde of Narrabeen, New South Wales, had to wait for Saturn to rise before he could see the very end of occultation. Although Saturn was still very low, Conde wrote that "at about 9:31:55 UT a soft, pearly point of light began to appear just inside the extremity of the eastern ansa. It was 28 Sagittarii shining through Cassini's division!"

Poor seeing concealed the star from Conde for several minutes, but he saw the star when it reappeared from behind the outer edge of the A ring. Conde attempted to time the reappearance. "Unlike a lunar occultation, where stars just blink on and off, 28 Sagittarii grew slowly in brightness," wrote Conde. "This, of course, made knowing when to halt my stopwatch rather difficult."

Canadian observer Todd W. Lohvinenko watched the occultation using his 8-inch f/10 SCT from Winnipeg, Manitoba. "I made a light curve from visual estimates of the star's brightness and made some interesting discoveries," said Lohvinenko.

"The A ring and B ring are both well defined and relatively dense," said Lohvinenko. "And except for one spike I saw, the B ring is extremely dense. I found that the C ring was somewhat more transparent than the other ring segments, and the gap between the C ring and the planet's globe blocked some of the star's light.

"Overall, I had a great time watching the Saturn occultation," said Lohvinenko. "Knowing that the star's flickering light represented light passing through ring material and gaps made it a very exciting experience that I'll never forget." — *David J. Eicher* ☐



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Telegraph Avenue comes to an end at the southern boundary of the University of California at Berkeley campus. A broad pedestrian boulevard continues north into the campus past the Student Union. It's late June and the campus is quiet.

At the end of the block-long boulevard, Sather Gate stretches across the entrance to the verdant campus and its imposing halls of learning. At the apex of the metalwork archway is a star with the words *Fiat Lux* imprinted across it. "'Let there be light,' said God; and there was light. And God saw that the light was good."

The 450 people gathered in Dwinelle 155 would all agree with God on that point. The multiformed sources of light scattered across the universe — moons, stars, galaxies, quasars — hold a special fascination for the people gathered in the large white-walled lecture hall. Some study these objects full time. Some teach others what is known about these objects. And some just enjoy contemplating all that wondrous light.

The Astronomical Society of the Pacific, on the occasion of its one-hundredth birthday, brought these people together for a special astronomical retreat on June 24 and 25. Nineteen popular lectures, dozens of exhibits by manufacturers and publishers, and an evening trip to historic Lick Observatory guaranteed an astronomy-rich weekend, but it was the chance to see the extraordinary variety of forms astronomy takes when filtered through the human mind and heart that made the event unique.

The ASP has been bringing the seemingly disparate elements of astronomy together since the day it was formed. The brainchild of a professional astronomer, Lick Observatory director Edward Holden, and a science teacher, Charles Burckhalter, the original members were largely San Francisco photography buffs who knew just enough about astronomy to photograph the January 1, 1889, solar eclipse for the observatory. (See related story on page 50.)

Today the ASP's membership, which, despite the organization's name, is spread throughout the United States and seventy other countries, is even more eclectic. "We are unique among scientific organizations in that we welcome anyone interested in the heavens into our society," said ASP executive director Andrew Fraknoi as he greeted those gathered in Dwinelle Hall. Some members had joined for the ASP's scientific journals, others for the slide sets and classroom materials the society produces. And some probably joined just so they could proclaim their enthusiasm for astronomy with the ASP's "I Watch Heavenly Bodies" bumper sticker.

For Janet Chisholm, astronomy is a thoroughly engrossing avocation. When she isn't trading currency at an Italian bank in Los Angeles, she's attending astronomy extension courses at UCLA or sitting in front of her Apple Macintosh running *MacStronomy* or reading Stephen Hawking's *A Brief History of Time* in a self-imposed challenge to decipher quantum physics.

I WATCH
HEAVENLY BODIES

Janet had passed up the three days of scientific meetings on galaxies, the interstellar medium, and the evolution of planetary systems that preceded the weekend of popular lectures. "I know my limits," she said unashamedly. Janet had her eye on the Lick Observatory tour and especially on the gift shop waiting for her there. Janet proudly reported how she and her fellow gift-shop raiders had cleaned out the shop at the Siding Spring Observatory in Australia during the ASP's Comet Halley trip.

For Jerry Nelson, astronomy is the challenge of building the largest telescope on Earth. Nelson is the principal designer of the Keck Observatory, the 10-meter telescope that will be completed in 1991. The observatory is now under construction on the 14,000-foot-high summit of Hawaii's Mauna Kea volcano.

Reporting on the progress of the telescope, Nelson said that making the mirrors had turned out to be the most difficult part of the project. The 10-meter mirror is made up of thirty-six individual mirror segments that are polished to six different shapes. Once the polished mirrors were cut into their final hexagonal shape, however, the glass distorted slightly and the mirror surface was no longer precise enough. Engineering ingenuity came to the rescue in the form of small "leaf springs" attached to the mirror supports that can be hand tightened to pull the mirror back into shape.

For Eric Chaisson, director of public affairs and educational programs at the Space Science Telescope Institute in Baltimore, astronomy is the excitement and the frustration of getting the *Hubble Space Telescope* into orbit. The launch of the telescope that will "rewrite the textbooks," according to Chaisson, had just been delayed again by a reshuffling of the shuttle schedule that moved a Department of Defense mission into the telescope's December 1989 slot and the telescope's launch back to March 1990.

"Space scientists are still playing second fiddle to the military," Chaisson said with obvious frustration.

On the bright side, Chaisson reported that he had recently been given the enviable task of selecting the first objects the general public will see from the *Space Telescope*. If all goes well, the telescope's wide field camera will take a few images (Chaisson called them the "pretties") as early as a few weeks after the telescope is in orbit.

For Frank Drake and Carl Sagan, astronomy is stretching the limits of what we know about ourselves. Both astronomers are asking questions that some believe are beyond our current capabil-

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ity to know: How did life get started on Earth and has life evolved elsewhere in the Galaxy?

Drake, president of the ASP and a long-time proponent of the search for extraterrestrial intelligence, or SETI, is quite matter-of-fact about our prospects for making contact with extraterrestrials. He estimates that there are 10,000 technological civilizations in our Galaxy with which we could communicate, and a new one emerges each year. If Drake's SETI program receives funding by NASA this year, we will begin searching for extraterrestrial radio signals on Columbus Day, 1992, and should make contact in the first decade of the twenty-first century, said Drake.

With equal certainty, Carl Sagan sought to convince the two thousand people who attended his public lecture on the origin of life on Earth that "we have to look off our planet if we are to understand where we came from." Sagan's premise is that the building blocks of life — organic compounds — arrived on Earth from somewhere else. His reasoning: there wasn't enough time between the formation of a solid crust on Earth and the emergence of the first complex life forms for these organisms to have developed from scratch. The original atmosphere on Earth also may not have had the right composition to produce organic material through natural processes, according to Sagan.

The implication is that if organic compounds fell on Earth from a comet or an asteroid, they could have fallen on other fertile planets and eventually evolved into advanced life forms. With the billions and billions of stars out there and the inevitable planets circling around some of them, it becomes statistically ludicrous to believe we are the unique example of advanced life in the universe, Sagan believes.

For some astronomers, however, certainty about the nature of the universe comes a lot more slowly and demands a lot more evidence. Bruce Campbell, an astronomer from the University of Victoria, has been observing a group of stars since 1981 in an effort to detect massive planets orbiting the stars. He has been looking for slight changes in velocity that could be caused by Jupiter-sized planets orbiting the stars. Although nine stars displayed changes, Campbell doesn't think this evidence is complete enough to say for sure that massive planets orbit these stars.

A whole series of increasingly accurate surveys would be needed before we could detect Earth-sized planets around other stars, said Campbell. This "slower track" to finding other planets may not promise the quick results that the SETI project does, but in Campbell's view it is much more likely to pay off in the end.

"This whole business of finding life elsewhere is really beyond science because it can't be pursued with the scientific method," Campbell said, commenting on the SETI project. He criticized Drake's estimates of extraterrestrial civilizations because they are based on a formula (the Drake equation) that relies on several essentially unknowable quantities, such as the life span of a technological civilization. "We would have to destroy ourselves to know how long that is," Campbell pointed out.

For Adriaan Blaauw, a Dutch astronomer who was honored at the ASP's centennial banquet for a lifetime of scientific achievement, astronomy is a pursuit in which our natural inquisitiveness inevitably outstrips our ability to know. "No matter how hard we astronomers try, the final answers we seek are always off in the future," said Blaauw. "So why do we do astronomy? We do it in order to make use of that great gift, the human mind, to study nature."

Timothy Ferris, author of *Coming of Age in the Milky Way,* characterized this pursuit of knowledge as "a dance or a dialog going on between mind and nature," suggesting the personal, free-form nature of the engagement and the resulting uncertainty of its outcome. In his talk on the conquering heroes of astronomy — Kepler, Galileo, Newton, and Einstein — Ferris described these scientists as men struggling to reconcile reason, observation, and "faith." For Kepler, faith was a belief in the beautiful structure underlying the universe. Newton believed in a powerful creator and he found support for his view of a Sun-centered universe in the Old Testament. Einstein demanded to know how God created the universe. These men were not the robo-intellects of scientific lore. They brought more to the table than pure reasoning ability and a fondness for data.

For Ed Krupp, astronomy is an inescapable human desire to find meaning in the sky, with or without the help of the scientific method. "Our ancestors reached for understanding from the sky and used it to put sense and direction into their lives," said Krupp, director of Griffith Observatory in Los Angeles and an authority on archeoastronomy. "Our brains still need this today."

Krupp described the importance of the pole star to many ancient cultures. As the one point in the sky that appeared fixed, the pole star became the symbolic center of the universe in these cultures' mythology, and ceremonial buildings and platforms were oriented to it as a way of connecting the community to the order of the universe.

Our own language displays that same connection with the sky in the positive connotations we give to the word "up": upgrade, upright, a machine is "up and running." The images of authority and exhilaration that our ancestors consciously attached to the heavens are still in use, at least subliminally, today.

"The idea of going up in the sky still has meaning," said Krupp, even though that meaning is not the same for us as it was for our ancestors. "The only difference is that they could only ponder the sky, we're trying to inhabit it."

For Jim Shaver and Fritz Ozell, astronomy is a calling to spread the word into the hinterlands of our culture. Ozell, a community college teacher from Hawaii, took this summer off from his usual college course to teach astronomy to twenty prison inmates. Shaver came down to Berkeley from British Columbia, where he gives interpretive programs on "birds, trees, and astronomy" to travelers stopping at a roadside campsite in Salmon Arm operated by the provincial parks.

For the people who journeyed up Mount Hamilton to Lick Observatory, astronomy was a pilgrimage. This was the place where intellect, invention, and inspiration all came together. Inside the dome of the 120-inch Shane reflector, astronomers rotated the dome and the massive telescope in preparation for the night's search for supernovae in distant galaxies.

Inside the observatory's 105-year-old Main Building, the small gift shop was packed with souvenir hunters carrying away T-shirts, coffee mugs, cloisonne pins, and posters. Janet Chisholm had scored a Lick centennial sweat shirt. "I just love observatories," she said.

At the southern end of the building is the dome of the 36-inch refractor, the largest telescope in the world a century ago. In the darkened basement, a small light illuminates the plaque marking James Lick's tomb in the base of the telescope's pier. Above, on the observatory's elevated wooden floor, a graduate student guides people single file to the eyepiece of the 36-inch scope.

The metal telescope tube fades into darkness as it stretches toward the open slit of the silent dome. Looking into the eyepiece, there is suddenly light: the telescope reveals the densely packed stars at the core of the globular cluster M5. And you saw that the light was good. — *Stephen Cole* ☐

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LOOKING OVER GALILEO'S SHOULDER

Sidereus Nuncius, or, The Sidereal Messenger, translated by Albert Van Helden, (University of Chicago Press, 1989), ISBN 0-226-27903-0, 127 pages, hardcover, $29.95; paperback, $7.95.

No backyard astronomer should miss Galileo's *Sidereus Nuncius*. By far the best time to read it is when you and your first telescope are still newly acquainted, but seasoned veterans will also enjoy the book. The *Nuncius*, which details Galileo's first astronomical discoveries with the newly invented telescope, has the feel of a "flash bulletin" — and if we make allowance for the speed of communications in the early 1600s, that's exactly how it worked.

Galileo wrote the book in Latin between early January and early March of 1610 in what must have been a state of continuous high excitement. Here he is viewing the Moon: "The area around the middle of the Moon is occupied by a certain cavity larger than all others and of a perfectly round figure. . . . It offers the same aspect to shadow and illumination as a region similar to Bohemia would offer on Earth, if it were enclosed on all side by lofty mountains."

And this about the Milky Way: "Disputes that for so many generations have vexed philosophers are destroyed by visible certainty, and we are liberated from wordy arguments. For the Galaxy is nothing else than a congeries of innumerable stars distributed in clusters. To whatever region of it you direct your spyglass, an immense number of stars immediately offer themselves to view."

This is why reading the *Nuncius* is best when you have recently bought your first telescope. When the sky and your telescope are fresh and new, there's no better way to get so close in spirit to Galileo's frame of mind when he wrote it.

The *Nuncius* went together quickly: Galileo's last observations for the book were made on the night of March 2, 1610, the printer finished running off all 550 copies on the 12th of the month, and the entire press run had sold out by the 19th! By early summer enough copies of the *Nuncius* and letters about its content had gone out from Italy that all of learned Europe had the news, and many astronomers had constructed telescopes and were making observations for themselves.

The most widely available English translation of the *Nuncius* is the one Stillman Drake published in his *Discoveries and Opinions of Galileo*. The translation is partial, however, and leaves out many of the Jovian moon observations. (It is still in print and is widely available in second-hand bookstores.) In 1983 Drake published a full translation in his *Telescopes, Tides, & Tactics*, but this book includes much interpolated material by Drake and is cast in the form of a dialogue. It is recognizably (and enjoyably) Galilean, but not pure Galileo.

Therefore, Albert Van Helden's new translation is very welcome. It's a handy little book that presents a complete English *Nuncius* in a clear and readable style. (The publisher, by the way, deserves big thanks for pricing the paperback edition inexpensively and for printing both editions on acid-free paper.)

Van Helden, a historian of science at Rice University, has carefully footnoted references in the text that might be obscure to today's readers. He has also written an excellent introduction that tells about the invention of the telescope in Holland and how Galileo heard of it and built his own. A concluding essay describes how the *Nuncius* was received by astronomers of the day.

Reflecting Galileo's characteristically headlong manner, the *Nuncius* abruptly breaks off: "Lack of time prevents me from proceeding further. The fair reader may expect more about these things soon." But "soon" never came. By the time he had more observations to report, Galileo was too deeply enmeshed in controversies over these discoveries and newer ones to prepare a second edition.

In the end, though, it didn't really matter: Galileo's "starry messenger" had done its work. The world now knew of lunar mountains, Jupiter's moons, and the stars and nebulae of the Milky Way. In just sixty pages, this incredible pamphlet yanked astronomy out of the grasp of antiquity and unfolded a new universe that lies in the eyepiece of every telescope, including yours and mine.

This is why even today, nearly four centuries after its publication, the *Sidereal Messenger* has the power to bring alive for every backyard astronomer the events of that momentous winter and to let us share so fully in Galileo's excitement.
—Robert Burnham

PHYSICS POTPOURRI

Science a la Mode: Physical Fashions and Fictions by Tony Rothman, (Princeton University Press, 1989), ISBN 0-691-08484-X, hardcover, 207 pages, $19.95

Tony Rothman's reputation stems from

his penchant for speculative physics. He aptly demonstrated this in the articles he coauthored for a previous book, *Frontiers of Modern Physics* (Dover, 1985), in which he accompanied the reader into a black hole and considered alternate universes. With *Science a la Mode* he again takes the reader on vicarious journeys through hypothetical physics.

Like *Frontiers, Science a la Mode* covers a wide range of topics, from cosmology to physics and even science politics. Although he covers some rather technical territory in places, most of the content will not be beyond the reader who has some knowledge of modern cosmology and basic astrophysical concepts.

Rothman starts off the book with a discussion of several cosmological models, including the anthropic principle and the "funhouse" model of the universe (a universe of mirrors), which Rothman evokes in a tongue-in-cheek explanation of the homogeneity of structures in the universe. He follows this with a chapter on "Metaflation," which is inflation — the idea that the universe experienced a sudden and rapid expansion just after the Big Bang — with a metaphysical twist.

The metaphysical overtones of inflation, Rothman argues, suggest that physics is approaching a "frontier where it is no longer based on experimental evidence and makes no predictions that are testable. Once this border is crossed, we have left the world of physics behind and entered the realm of metaphysics."

Other chapters include an architectural approach to the geometry of space-time by considering the structure of geodesic domes and the apparent contradiction between entropy and Newtonian mechanics (it's not as stuffy as it sounds). He then shifts gears by weighing the conscience of the scientist. He asks: Should scientists support theories that, though scientifically inaccurate, might somehow help humanity in the long run? Rothman refers to the nuclear winter theory championed by many scientists, but which is thought by other scientists to be nothing more than speculation without a firm scientific foundation.

Despite the speculative content, Rothman keeps a tight rein on reality and the laws of physics so the reader never loses his reference point. This mixture of whimsy and lucidity in *Science a la Mode* gives the book its shine. Rothman tinkers around with the universe, plays with time, and taxes the reader's imagination in the process. But if Rothman didn't stretch our minds like this, the book wouldn't be worth reading. — *Jeff Kanipe* ☐

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DEEP-SKY DATABASE

Deepsky 2000 version 1.1, (Tumasoft Software, 6 Forest Park East, Jacksonville, IL 62650), PC compatibles with MS/DOS operating systems, $39.95.

Deepsky 2000 is a useful computer program with one main function: it provides custom-selected tables of deep-sky objects for use at the telescope. The database contains 1,480 objects, 25 of which are bright stars for initializing your scope's setting circles. There are no double stars, variable stars, or dark nebulae in the database, but the program does provide a way for you to add objects, so you could include them if you like.

The program's good points include an installation routine that works well: the program worked the first time we tried it on both color and monochrome monitors. Also, the menus make it easy to search the data. For example, you can ask the program to look for planetary nebulae in all constellations or just those in Virgo. With an XT clone at 8 MHz, it took 2 minutes for the program to search the entire file.

The program has other nice features. The menu for choosing the final printout provides plenty of choices for a variety of observing list formats, and the program accepts either upper or lower case constellation names.

Deepsky 2000 does have drawbacks. You can enter only fifty characters of observing notes on each object. (This is obviously not going to be enough for the Andromeda Galaxy or the Orion Nebula.) If the printout routine allowed you to insert several carriage returns after each object, you would have room for notes at the eyepiece. Second, the values you input to search on are not checked for absurdities. If you tell it to look for nonexistent objects such as NGC 8000, it will do so.

Many objects show a magnitude of 0.0, which really means that no magnitude was found in the sources used by the author — of which only the old *Atlas Coeli Catalogue*, published in 1959, is mentioned. If you are scanning a constellation list and run past something that catches your interest, you can't scroll the listing back but must go forward to the end and start over from the beginning.

The data have a few errors. For instance, NGC 40 is listed in Cassiopeia, it is actually in Cepheus. There are also typos: several of the planetary nebulae have an upper case "S" for seconds of arc, when a lower case "s" is used everywhere else.

The program's manual is contained on the disk in a file that can be printed or read with a word processor. The manual does a good job of telling a novice computer user how to get the program working.

Many ASTRONOMY readers observe from urban or suburban backyards with scopes ranging up to about 10-inches aperture. These observers frequently rely on *Burnham's Celestial Handbook*, a familiar and constant companion to many lovers of deep-sky objects. *Deepsky 2000*'s database has about the same number of objects as *Burnham's*, so the database is large enough to provide objects and observing programs for such an observer for many years.

On the other hand, die-hard deep-sky observers, who are willing and able to drive to dark skies and use large-aperture telescopes to look for scads of faint objects, need celestial object lists that run far beyond what *Burnham's* provides. These observers will probably find *Deepsky 2000* less useful because its limited database isn't as comprehensive as what they need.

However, a suburban observer with a medium-sized scope and no wish to type in data on 1,500 objects might gladly spend the $40 and put up with the (relatively few) restrictions. — *Bill Anderson, A. J. Crayon, and Steve Coe*

COMETS IN THE CARDS?

Good Heavens!, (Ampersand Press, 691 26th St., Oakland, CA 94612), deck of 54 cards, 24-page booklet, $7.95 (plus $2.75 shipping).

Good Heavens! is a card game designed to teach some simple facts about astronomy. It is aimed at ages ten to adult, though obviously bright kids younger than ten could follow the game and get something out of it. The deck has fifty-four cards, each with a question, its answer, and an explanation. Each card also lists sample answers to a few questions on other cards, some correct and some deliberately wrong to provoke discussion.

The questions are pretty basic. "The astronomer Halley's first name? *Edmond.*" "Shooting stars or falling stars are not stars at all. What are they called? *Meteors.*" "The Great January Comet of 1910 was Halley's comet. True or false? *False.*" Finding that the short, one- or two-word answers were rather restrictive,

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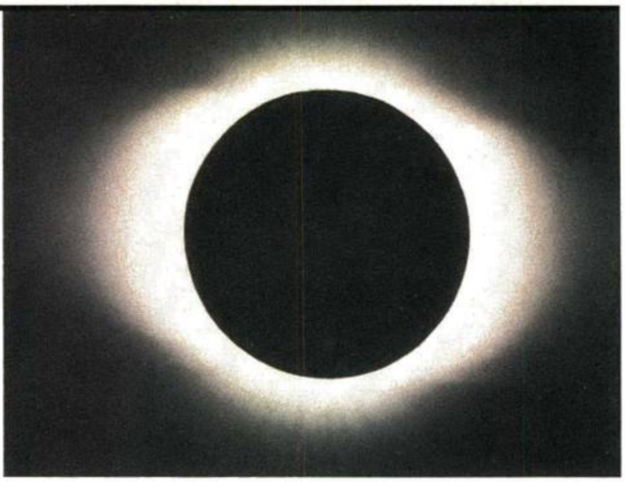
I found myself wishing for questions that demanded more thoughtful responses.

Of the fifty-four cards in the set, thirty-five are on comets, ten are on the solar system, and nine deal with astronomers. If I were using the game to help teach astronomy, I would want a wider range of subjects. For example, the universe outside the solar system is ignored totally. Moreover, the heavy dose of comets will make the set seem out of date now that Halley is gone. Perhaps Ampersand could find a market for a general astronomy card game with a wider focus.

If they do, I hope they avoid one flaw I see in this set. Too many cards have questions that quibble over definitions. For instance, one reads "Which of the planets may actually be a comet? *Pluto.*" That particular answer is oversimplified, to say the least. But aside from that, I find this kind of question smacks of classrooms in which "learning" consists of memorizing arbitrary definitions and "getting the right answer" depends on spotting which definition applies.

Kids educated with this approach are led to think that when they have mastered definitions, they have achieved understanding. However, in astronomy at least, all the interesting stuff happens in the gray areas where the definitions let you down. I'd like to see more astronomical education materials that recognize this distinction. — *Robert Burnham* ☐



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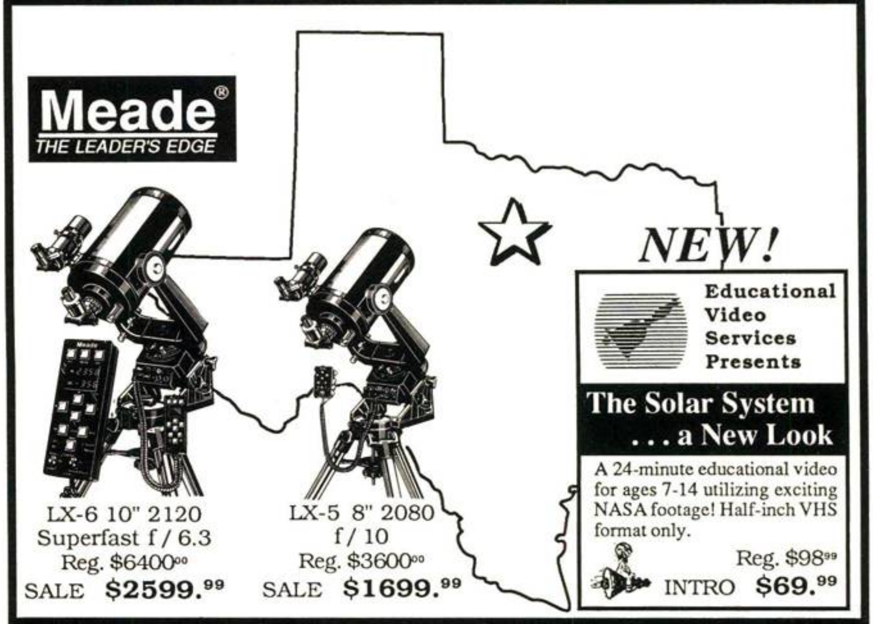

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Meetings and Events

September 20-23
Le Ciel et L'Espace, Aniane Observatory, Montpellier, France. Contact: Bernard Pellequer, Astronomical Observatory, BP 14, 34150, Aniane, France.

September 22-23
Astronomy Weekend, Button Bay State Park, Vergennes, Vermont. Sponsored by the Vermont Astronomical Society. Contact: P.O. Box 782, Williston, VT 05495.

September 22-24
3rd Annual Whirlpool Star Party, Birr, County Offaly, Ireland. Sponsored by the Limerick Astronomy Club. Contact: Tony O'Hanlon, 54 Ballycannon Heights, Meelick, County Clare, Republic of Ireland.

September 27-October 1
6th Annual Okie-Tex Star Party, Lake Murray State Park, Ardmore, Oklahoma. Sponsored by the Oklahoma City Astronomy Club. Contact: Oklahoma City Astronomy Club, P.O. Box 21221, Oklahoma City, OK 73156.

September 29-30
Hidden Hollow, Warren Rupp Observatory, Mansfield, Ohio. Sponsored by the Richland Astronomical Society. Contact: P.O. Box 653, Ashland, OH 44805.

September 29-30
1989 Iowa Convention of Amateur and Professional Astronomers, Ames, Iowa. Hosted by the Ames Area Amateur Astronomers and the Iowa State University Astrophysics Group. Contact: John Burnett, 1214 Curtiss Avenue, Ames, IA 50010.

September 29-October 1
I.A.P.P.P. Conference, Wichita, Kansas. Photoelectric photometry, variable stars, and data collection and reduction featured. Contact: Thomas L. Burgin, 2101 Rosalie, Wichita, KS 67207. Phone: (316) 685-0518.

September 29-October 1
Stella-Della-Valley III, Ottsville, PA. Sponsored by the Bucks-Mont Astronomical Association and the Mideast Region of the Astronomical League. Contact: Connie Beck, Open Gate Farm, RD 2, Box 261, Perkasie, PA 18944. Phone (215) 795-2125.

September 30-October 1
5th Annual Blue Ridge Parkway Regional Stargaze, Part One, Julian Price Park, North Carolina. Sponsored by the Catawba Valley Astronomy Club. Contact: Greg Kirby, 12 East Street, Granite Falls, NC 28630. Phone: (704) 396-7656.

September 30-October 1
NIAG '89, South Bend, Indiana. Sponsored by the Northern Indiana, Michiana, Fort Wayne, and Warsaw astronomical societies. Contact: Greg O'Neil, P.O. Box 6004, Fort Wayne, IN 46896 or Dan Smith, P.O. Box 262, South Bend, IN 46624. Phone: (219) 282-1086.

October 12-14
17th Annual Great Plains Planetarium Association Conference, University of Nebraska, Lincoln, Nebraska. Sponsored by the Great Plains Planetarium Association. Contact: Jack Dunn, Ralph Mueller Planetarium, 210 Morrill Hall, University of Nebraska, Lincoln, NE 68588. Phone: (402) 472-2641.

October 18-21
25th Annual Great Lakes Planetarium Conference, Parkland College, Champaign, Illinois. Contact: David Linton, William S. Staerkel Planetarium, Parkland College, 2400 West Bradley Avenue, Champaign, IL 61821. Phone: (217) 351-2568.

October 21
Starfest '89, Bays Mountain Park, Kinsport, Tennessee. Contact: Rick Eldreth, 1211 Imperial Drive, Kinsport, TN 37663. Phone: (615) 239-6376.

October 26-29
Deep South Regional Stargaze, Percy Quin State Park, McComb, Mississippi. Sponsored by the Jackson Astronomical Association. Contact: Jeff Somers, 414 Woody Drive, Jackson, MS 39212. Phone: (601) 372-2275.

October 27-29
Astronomy Jamboree, Custer Institute, Southhold, New York. Contact: Tom Carey, Vanderbilt Planetarium, Centerport, Long Island, NY 11721. Phone: (516) 262-7807.

October 28-29
5th Annual Blue Ridge Parkway Regional Stargaze, Part Two, Julian Price Park, North Carolina. Sponsored by the Catawba Valley Astronomy Club. Contact: Greg Kirby, 12 East Street, Granite Falls, NC 28630. Phone: (704) 396-7656.

Please submit announcements at least four months before the date of the meeting or event.

When you write to organizations listed in Meetings and Events, include a self-addressed, legal-size envelope with your request for information. □

READER EXCHANGE

ANNOUNCEMENT – The Ches-Mont Amateur Astronomers Association, located in Norristown, Pennsylvania, seeks new members. For more information, phone Dan at (215) 631-0279 evenings.

ANNOUNCEMENT – Free astronomy tract. Send S.A.S.E. to P. R. Signorelli, P.O. Box 6069, Colorado Springs, CO 80934-6069.

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ANNOUNCEMENT – Free computer bulletin board dedicated to astronomy. Phone (501) 569-3022 from 4:30 p.m. to 8:30 a.m.

ANNOUNCEMENT – The Mid-South Astronomical Research Society (MARS), the central Arkansas astronomy group, meets on the second Saturday of each month at the UALR Planetarium at 5:30 p.m. Contact P.O. Box 5142, Little Rock, AR 72225. Phone (501) 372-1367.

WANTED – Address information on Pennwood Numechron Clock & Telescope Co., Pittsburg, PA. Contact Scott E. Siglin, 1005 Prospect Boulevard, Waterloo, IA 50701.

WANTED – Sixteen-year-old amateur seeks correspondence with other teens interested in astronomy, science fiction, shortwave radio, extraterrestrial life, or old movies. Answer guaranteed. Contact Mike Joy, 8473 Highway Z, Custer, WI 54423.

WANTED – Correspondence with individuals interested in amateur astronomy and space exploration. Other topics at your request. Preferrably outside the United States, but no letter will go unanswered. Write in French or English. Contact Edward A. Locke, P.O. Box 1883, Columbia, TN 38401.

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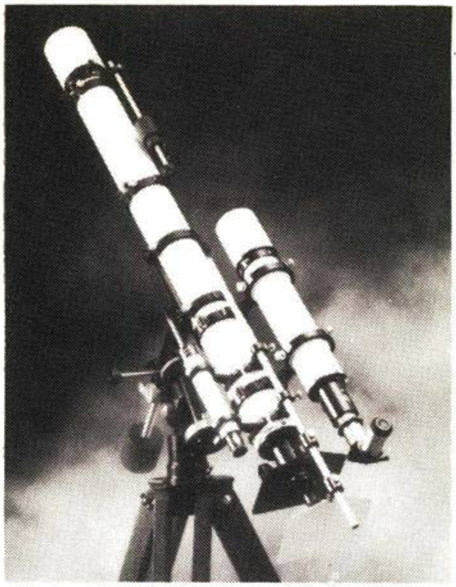
WANTED – Correspondence with amateur astonomers. Contact Armand Rivera, A.A. 40058, Bogota, Columbia.

WANTED – Form 4 high school student in Zimbabwe would like guidance and assistance for his examinations in astronomy. Needs question papers from the past three years and any other materials. Contact Daishik Chauhan, 5 Plumer Street, North End, Bulawayo Zimbabwe.



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Readings and Resources

The Looking Glass (page 20)

The Symbiotic Universe by George Greenstein, (William Morrow and Company, Inc., 1988). Greenstein examines how, against all odds, our universe came into existence. Chapter eleven concerns grand unification and inflation.

"Particle Physics and Inflationary Cosmology" by Andrei Linde, *Physics Today,* September 1987. A semitechnical explanation of the "physics" behind self-replicating universes.

Ancient Martian Floods (page 38)

The Channels of Mars by Victor Baker, (University of Texas Press, 1982). The standard work on Martian valley systems and outflow channels; profusely illustrated with photographs and maps.

Devoted to Astronomy (page 50)

Eye on the Sky by Donald E. Osterbrock, John R. Gustafson, and W. J. Shiloh Unruh, (University of California Press, 1988). The official history of Lick Observatory; includes descriptions of the observatory's 1889 eclipse expeditions.

The Astronomical Society of the Pacific, 390 Ashton Avenue, San Francisco, CA 94112; phone (415) 337-1100.

Small Refractors (page 80)

The Adjustment and Testing of Telescope Objectives by H. Dennis Taylor, (Adam Hilger, 1983). More useful information on achromat refractors than you will find anywhere else.

"The Mount of Gibraltar" by Rick Shaffer, ASTRONOMY, August 1988. Tells how to beef up that mounting and get a little stability back into your astronomical equipment. (Might have been titled "Making Lemonade, Part 1.")

"The Refractor Advantage: Quality over Size" by Alan Dyer, ASTRONOMY, October 1987. Explains why good refractors are booming in popularity again.

"Soup Up Your Small Scope" by Rick Shaffer, ASTRONOMY, September 1988. "Making Lemonade, Part 2" tells what to do about that awful finder scope and those crummy eyepieces. ☐

CREDITS

Cover: Anglo-Australian Telescope Board; *page 4:* Michael Shin (50mm f/2.8 lens, 7-minute exposure, Kodak VR-1000 film, August 13, 1988); *page 10:* National Optical Astronomy Observatories; *page 14:* European Southern Observatory; *page 16:* TRW; *page 18:* Trey Mitchell; *pages 22-28:* illustrations by Paul DiMare; *pages 33-34:* Jet Propulsion Laboratory; *pages 38-45:* courtesy of Mark S. Robinson, University of Hawaii; *page 51:* courtesy of Carter W. Roberts; *pages 52-54:* courtesy of the Shiloh Unruh Collection; *page 65:* Thomas Rotkiewicz (12-inch f/16 Cassegrain telescope using eyepiece projection, 4-second exposure, SO-115 film; *pages 70, 81, 87:* Art Schmidt; *page 88:* illustration courtesy of Celestron International; *page 93:* Jack Newton (16-inch f/5 reflector); *page 94:* Tony Hallas and Daphne Mount (11-inch f/10 SCT, hypered Tech Pan film); *page 94, top:* Mace Hooley (8-inch f/1.5 Schmidt camera, Fujichrome 100 film), *bottom:* Martin C. Germano (8-inch f/10 SCT, 103a-F film); *page 99:* sketches by Bob Talaga; *page 103:* Robert D. Walton (C11 telescope using eyepiece projection to f/55, Kodak Tech Pan 2414 film developed 8 minutes in D-19); *page 106:* illustration by Greg Kot.

READER EXCHANGE

WANTED – 18 year old seeks correspondence with amateur astronomers worldwide. Particularly, people interested in the Moon, the planets, and astronomical history. Contact David R. Sommerville, Stable Cottage, Glanarberth, Llechryd, Dyfed, Wales, United Kingdom SA43 2QG.

WANTED –.Hardcover 1950s science fiction novels in any condition published by John C. Winston Co. Novels written by Donald Wollheim, Raymond Jones, Arthur Clarke, Lester del Rey, Richard Marsten, and others. Contact Michael Joy, 8473 Highway Z, Custer, WI 54423.

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FOR SALE –6″ f/8 Edmund Scientific parabolic mirror and diagonal with Novak research cell, spider, and Meade 1.25″ focuser. Good starter package. $150 plus shipping. Contact David Blink, 2632 Wooster Court, Vienna, VA 22180. Phone (703) 876-1627 (evenings).

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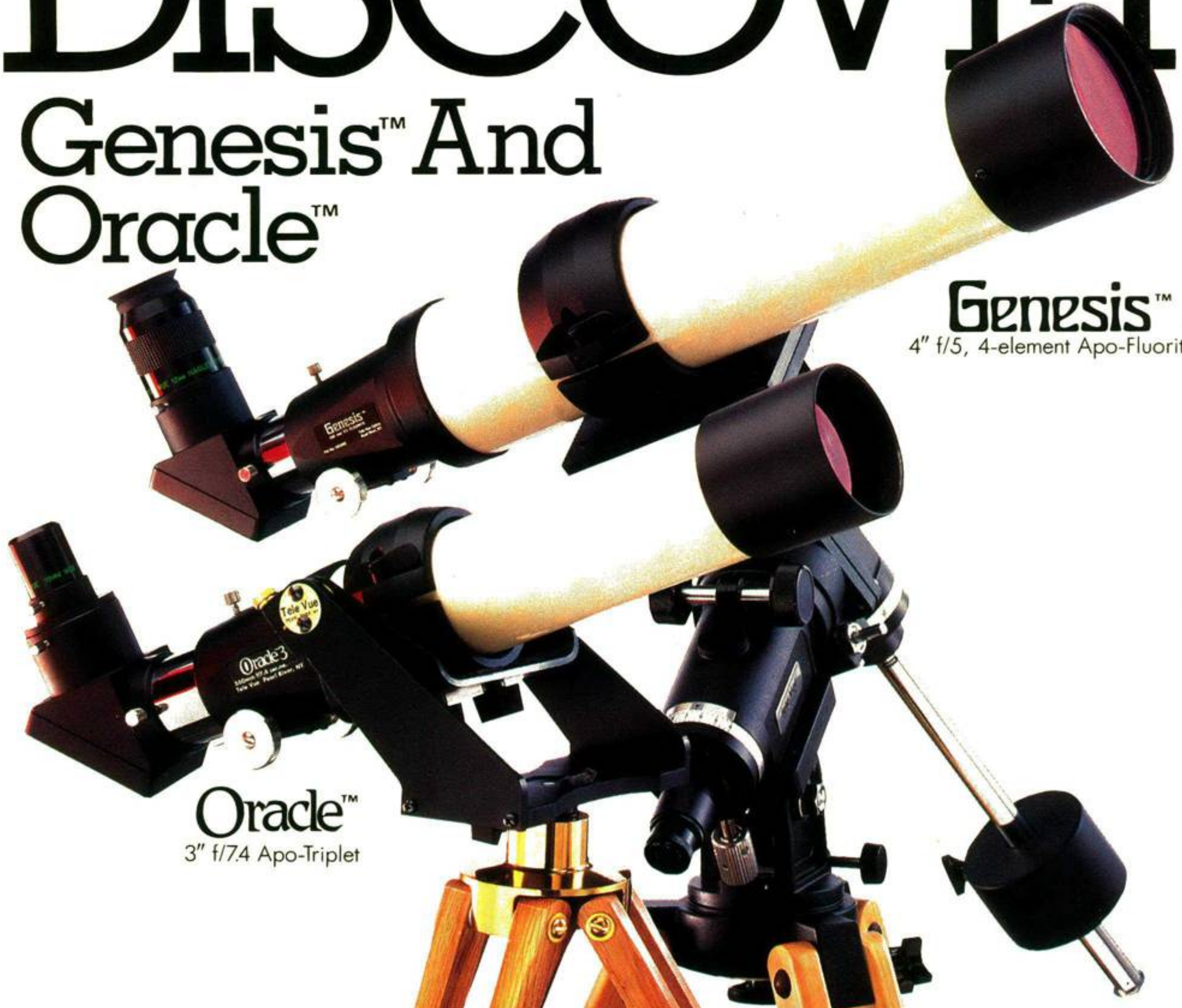

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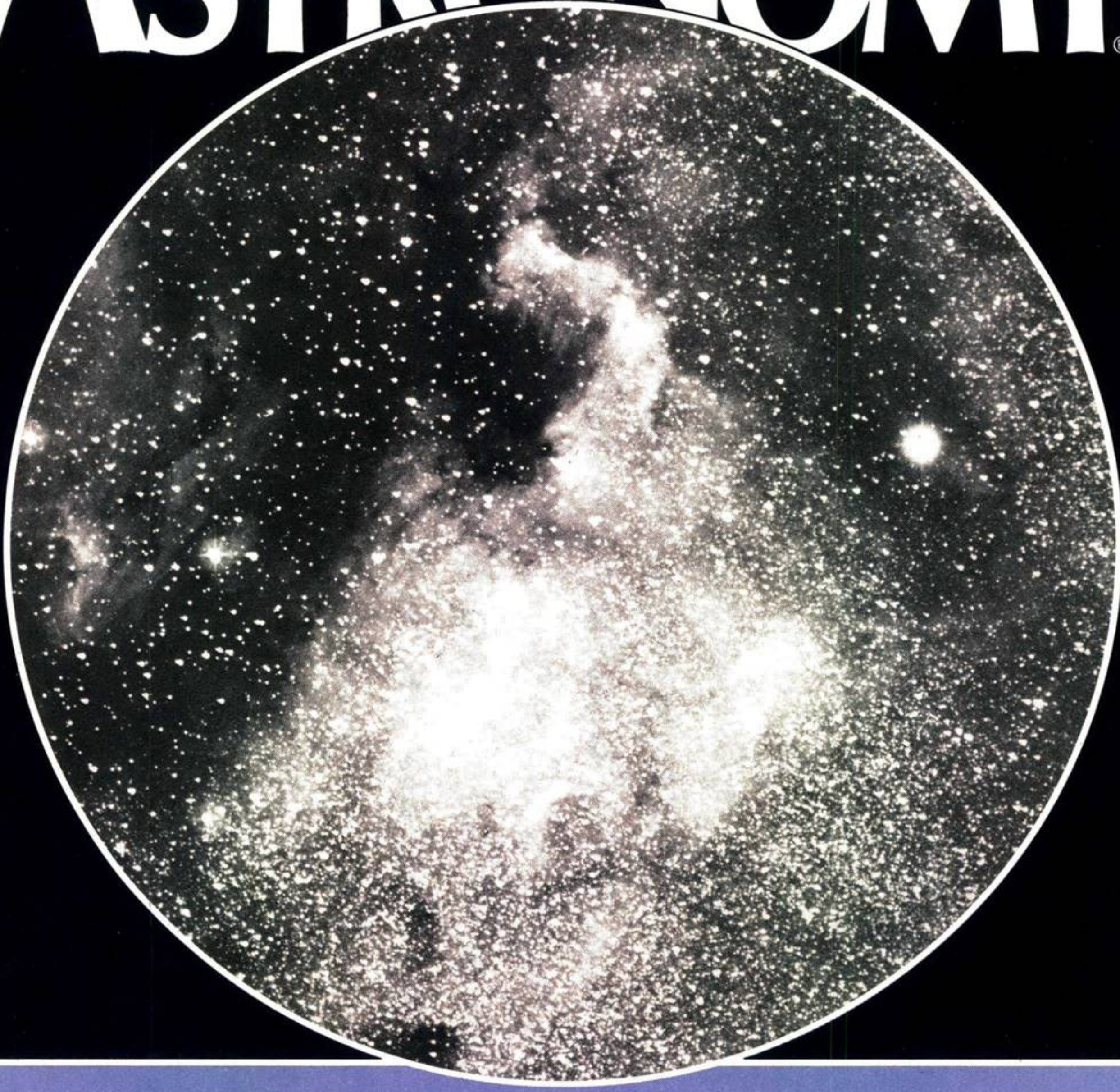

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Tucson, AZ 85726
(602) 882-8804
MD Me

Novagraphics
P.O. Box 37197
Tucson, AZ 85740
(602) 888-2424
RD MD Av

Nuart Photo Service
43 El Con Center Mall
Tucson, AZ 85716
(602) 327-7062
RD Av,Bi,Bk,Ca,Ey,Fm,Fl,Mr,Mn,Ph,
Pl,Rp,Mp,Te,Ta

Stellar Vision
1835 South Alvernon #208
Tucson, AZ 85711
(602) 571-0877
RD MD Do,Ey,Rp,Mp,Te,Ta,Tm

Tri-City Camera Exchange
500 West Southern Avenue
Mesa, AZ 85210
(602) 964-1380
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Western Research Company
2127 East Speedway Boulevard, #209
Tucson, AZ 85719
(602) 325-4505
MD Bk,Ca,Sf,El,Sc

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Phoenix, AZ 85016
(602) 955-6773
RD MD Bi,Bk,Ca,Ey,Fm,Fl,Mr,Mn,
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Mesa, AZ 85201-4464
(602) 962-4789
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RD Bi,Ca,Fm,Ph

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MD Mn,Rp,Te,Ta

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(707) 874-2352
MD Bk,Sf

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(415) 654-8204
MD Sf

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Fm: Film Processing
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MD Sf

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Ey: Eyepieces
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RD Bi,Bk,Ca,Ey,Fm,Fl,Ph,Mp,Te,Ta

TEXAS

Analytical Scientific
P.O. Box 198, Helotes, TX 78023
(512) 684-7373
RD MD Bi,Bk,Ey,Fl,Mp,Te,Ta

Astral Projections
P.O. Box 9242, Fort Worth, TX 76147
(817) 737-8755
MD Me

Austin Business Computers
3006 Bee Caves Rd., Suite C-175
Austin, TX 78746
(512) 328-4747
RD Av,Sf,Te,Ta

Bill Weaver Sporting Goods
3515 W. Vickery, Fort Worth, TX 76107
(817) 731-0804
RD MD Bi,Ey,Mp,Te,Ta

Bob Hawley's Camera Crafts
5453 Burnet Rd., Austin, TX 78756
(512) 451-7911
RD Av,Bk,Ca,Fm,Fl,Ph,Rp

Computer Mart
105 Lynn St., Nacogdoches, TX 75961
(409) 560-2826 (800) 443-8236
MD Sf

Deen Publications
P.O. Box 831991
Richardson, TX 75081
(214) 231-0338
MD Sc

Earth Science Calendars
Box 835, Lamesa, TX 79331
(806) 872-2764
RD MD Sc

Fireball Electronics
246 E. 52 St., Odessa, TX 79762
(915) 366-4802 (800) 592-4561
(800) 351-1574
RD Me

Harris Hobbies
P.O. Box 850237
Richardson, TX 75085-0237
(214) 690-4943
MD Bk,Sf,Ey,Fl,Ph,Mp,Te,Ta

Karl's Camera Inc.
P.O. Box 7819, Tyler, TX 75701
(214) 561-4154
RD Bi,Bk,Ca,Ey,Fm,Fl,Ph,Te,Ta

Lunar & Planetary Institute
3303 Nasa Rd. 1, Houston, TX 77058
(713) 486-2143
MD Bk

National Assoc. of Space Educators
Route 9, Box 810-S
Canyon Lake, TX 78133-5122
(512) 899-3290
MD Bk

Rose Star Products
2913 Teaque Dr.
Tyler, TX 75701
(214) 592-5218
MD Ta

Sky Designs
4100 Felps, Ste. C, Colleyville, TX 76034
(817) 581-9878
RD MD El,Ey,Mn,Te

Space Images
P.O. Box 58694, Houston, TX 77258
(713) 474-5762
MD Av

Tau Ceti Co.
P.O. Box 1101, Conroe, TX 77305
(409) 539-4073
MD Ca,Ph,Ta

Texas Nautical Repair
2129 Westheimer St.
Houston, TX 77098
(713) 529-3551
RD Bi,Bk,Ca,Ey,Fl,Mr,Mn,Rp,Sc,
Mp,Te,Ta

The Nature Place
603 Munger, Ste. 308, Dallas, TX 75202
(214) 954-0604
RD Bi,Bk,Pl,Sc,Mp,Te

V P Company
7715 Chattington Dr., Dallas, TX 75248
(214) 661-3255
RD MD Bk,El,Ey,Fl,Mr,Mn,Op,Ph,Rp,
Mp,Te,Ta,Tm

WSD Technologies
P.O. Box 220464, El Paso, TX 79913
(915) 833-3551
RD MD Fm,Op

Z Optical Shop
2829 North Main, Stafford, TX 77477
(713) 499-4993
RD Bi,Bk,Ct,Ey,Fl,Me,Mr,Mn,Op,
Rp,Mp,Te,Ta,Tm

UTAH

Hammond Hobby
Cottonwood Mall
Salt Lake City, UT 84117
(801) 278-0157
RD Bi,Ey,Fl,Te,Ta

Hammond Hobby
50 South Main Crossroads Mall
Salt Lake City, UT 84101
(801) 531-6074
RD Bi,Bk,Ey,Fl,Sc,Mp,Te,Ta

Hansen Planetarium
15 S. State Street
Salt Lake City, UT 84111
(801) 538-2242
RD MD Av,Bk,Mp

Hansen Planetarium Publications
1098 S. 200 W.
Salt Lake City, UT 84101
(801) 538-2242 (800) 321-2369
RD MD Bk,Mp

Inkley's
1984 South State Street
Salt Lake City, UT 84115
(801) 486-5901
RD Av,Bi,Ca,Sf,Ey,Fm,Ph,Rp,Mp,Te,Ta

VERMONT

Bennington Photo Supply
Box 740, Bennington, VT 05201
(802) 442-3609
RD Bi,Ca,Fl,Ph,Rp,Te

Green Mountain Cameras
1 Towne Marketplace
Essex Junction, VT 05452
(802) 879-3211
RD Bi,Ca,Fm,Fl,Mr,Ph,Te,Ta

VIRGINIA

A.M. Plastics
405 Tulip Poplar Lane
Fredericksburg, VA 22401
(703) 373-3919
MD Ph

Celestial Products
10 West Washington Street
Middleburg, VA 22117
(703) 687-6881 (800) 235-3783
RD MD Av,Bk,Sf,Sc,Mp

Challenger Center
1101 King Street, Suite 190
Alexandria, VA 22314
(703) 683-9740
RD MD Bk,Cj,Sf,Ph,Sc,Mp,Tr

Ewald-Clark, Inc.
2140 Colonial Avenue S.W.
Roanoke, VA 24015
(703) 344-9055
RD Av,Bi,Ca,Fm,Fl,Ph,Rp,Te,Ta

Gentry Studio of Blacksburg
206 Draper R., Blacksburg, VA 24060
(703) 552-2319
RD Av,Bi,Ca,Ey,Fm,Fl,Mr,Ph,Rp,Te,Ta

Hampton Hobby House
Coliseum Mall A3B
Hampton, VA 23666
(804) 826-3400
RD Bi,Bk,Ca,Fm,Fl,Ph,Rp,Te,Ta

Redlich Optical
2319 Wilson Boulevard
Arlington, VA 22201
(703) 527-5151
RD MD Bi,Bk,Ca,Ey,Fl,Mr,Mn,Ph,Rp,
Sc,Mp,Te,Ta,Tm

Time-Life Books
777 Duke Street
Alexandria, VA 22314
(703) 838-7000
MD Bk

WASHINGTON

Aries Optics
Route 1, Box 143G, Palouse, WA 99161
(509) 878-1713
MD Bi,Ey,Fl,Te,Ta

Clyed s Camera Store
1410 4th Avenue, Seattle, WA 98111
(206) 624-4090
RD Bi,Bk,Ca,Fm,Fl,Ph,Rp,Te,Ta

Harold Tymer Co., Inc.
1601 Broadway, Vancouver, WA 98663
(206) 695-9534
RD Bi,Bk,Ca,Fm,Fl,Ph,Rp,Te,Ta

K.B. Systems
10407 62nd Place W., Everett, WA 98204
(206) 355-8740 (800) 423-9677
MD Ph,Ta

Kenmore Camera
P.O. Box 82467, Kenmore, WA 98028
(206) 485-7447
RD MD Av,Bi,Bk,Ca,Ey,Fm,Fl,Ph,Rp,Te,Ta

Microscience International
31101 - 18th Avenue South
Federal Way, WA 98003
(206) 941-7976
MD Sf,Sc,Mp

Robi s Camera Center, Inc.
10102 Bristol Avenue SW
Tacoma, WA 98499
(206) 584-0210
RD Bi,Bk,Ca,Fm,Fl,Mr,Ph,Rp,Te,Ta

Wasem's, Inc.
800 6th Street
Clarkston, WA 99403
(800) 548-2804
RD MD
Av,Bi,Ca,Ey,Fm,Fl,Mn,Ph,Rp,Te,Ta

WEST VIRGINIA

Commercial Sales Inc.,
dba Bernie Glenn
348 National Road
Wheeling, WV 26003
(304) 232-2828
RD Av,Bi,Ca,Cj,Fm,Fl,Ph,Te

World of Science
Charleston Town Center Mall
Charlestonve, WV 25389
(304) 345-2651
RD Bi,Sc,Mp,Te,Ta

WISCONSIN

Chest Works
1391 North 72nd Street
Milwaukee, WI 53213
(414) 476-6986
RD MD Cj

Eagle Optics
6109 Odana Road
Madison, WI 53719
(608) 271-2444 (800) 289-1132
RD MD Bi,Ey,Mp,Te,Ta

Galaxy Science & Hobby Center, Inc.
756 Northland Mall
Appleton, WI 54914
(414) 730-9220
RD Bi,Bk,Ey,Fl,Me,Mr,Mn,Op,
Rp,Sc,Mp,Te,Ta,Tm

Kenneth Novak & Co.
Box 69
Ladysmith, WI 54848
(715) 532-5102
MD Bk,Mr,Mn,Ta,Tm

Sky Forum
1391 North 72nd Street
Wauwatosa, WI 53213
(414) 476-6986
RD MD Bk

WYOMING

Jackson Hole Aviation
P.O. Box 3829
ackson, WY 83001
(307) 733-4767
RD Bi,Cj,Ey,Fl,Mn,Mp,Te,Ta

Unicover Corp.
1 Unicover Center
Cheyenne, WY 82008-3232
(307) 634-5911
MD Cl

RD: Retail Dealer
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Av: Audio-Visual Products
Bi: Binoculars
Bk: Books & Publications
Ca: Cameras
Cj: Clothing & Jewelry
Ct: Coatings
Cl: Collectibles
Sf: Computers & Software
Do: Domes & Observatories
El: Electro-Optical Equipment
Ey: Eyepieces
Fm: Film Processing
Fl: Filters
Me: Meteorites
Mr: Mirrors & Lenses
Mn: Mounts
Op: Optical Design & Engineering
Ph: Photo. Equipment & Accessories
Pl: Planetariums
Rp: Repair Services
Sc: Science Products
Mp: Star Maps & Atlases
Te: Telescopes
Ta: Telescope Accessories
Tm: Telescope Making Supplies
Tr: Travel & Tours